Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JUNE, 1954

TECHNOLOGY DEPT.

TABLE OF CONTENTS, Page 43

HOT STRIP MILL for Fairless Works, U. S. Steel Corporation

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Mesta 80" Continuous Hot Strip Mill Finishing Stands

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In introducing Cutler-Hammer's New Flat Master, we don't have to tell an experienced steel man the advantage of being able to mount masters on 7½" centers. The New Flat Master is only 6 15/16" at greatest depth. This means these masters can be grouped in such a short span, the operator has any one in easy reach without stretching at all. It means he doesn't get so tired. It means his efficiency stays high.

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These are but two of the many features making the Flat Master ideal for crane cab, open hearth charging machine and "all-vision" cab use. The Flat Master is designed throughout the better to meet steel mill needs. The rugged substantial cover lifts off straight up. The contact structure is simplified, all parts easily accessible, and easy to maintain. Movable and stationary contacts are readily replaceable, or the group assembly of 3 sets of contacts and operating rollers can be easily replaced as a unit. Twin break special alloy contacts, arc resistant molded supports, etc., provide long contact life and trouble-free service. There is ample wiring space. The sealed bearings are permanently lubricated. Many other features of fine, dependable performance recommend you get further information at once. CUTLER-HAMMER, Inc., 1269 W. St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

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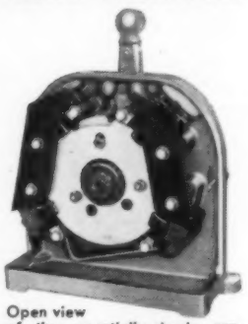
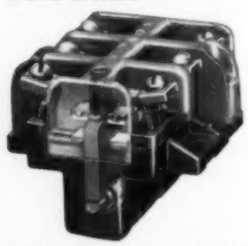
MOTOR CONTROL
C-H



Open view of the essentially simple construction of the New Flat Master and standardized contact structures that provide 5 speed points in either direction.



Phantom view of one of 4 contact structures that are interchangeable with many other C-H masters and switches. Standardized, simplified, sturdy.

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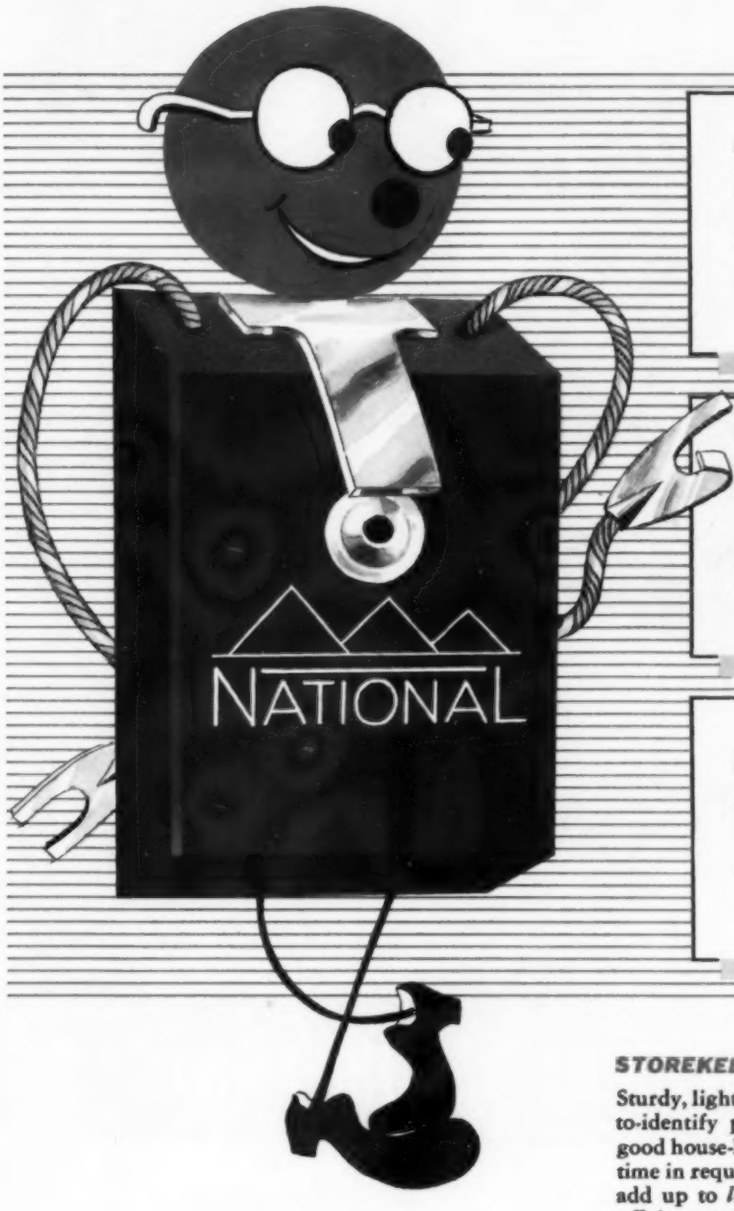

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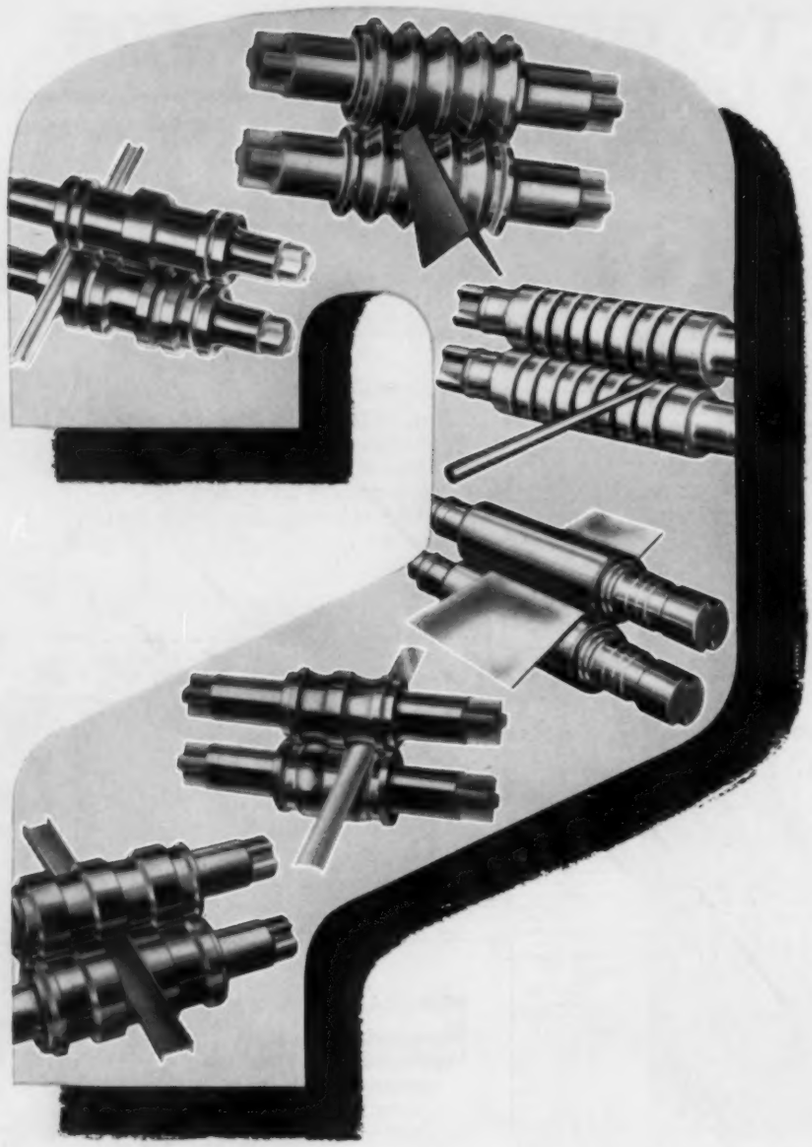

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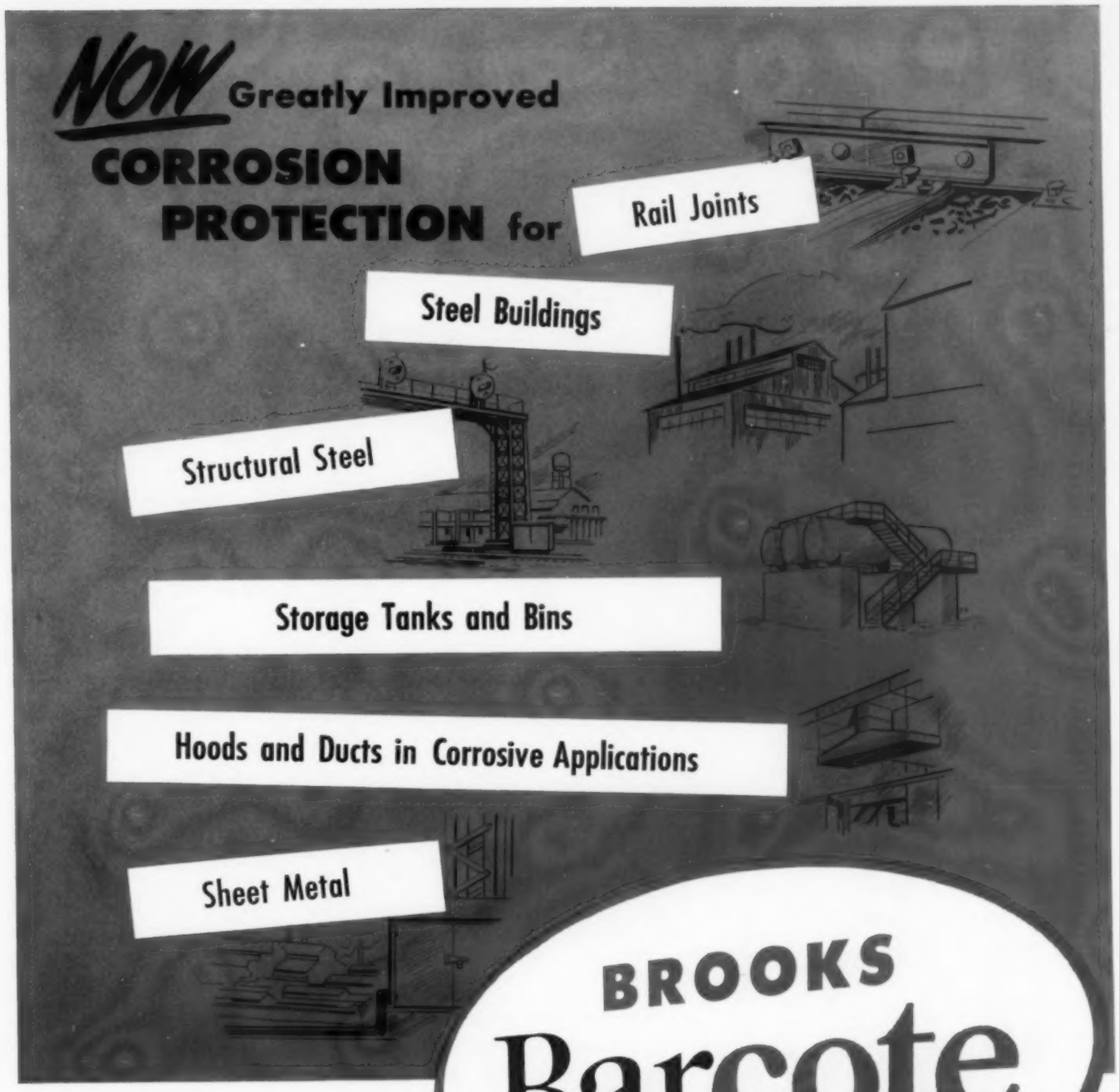

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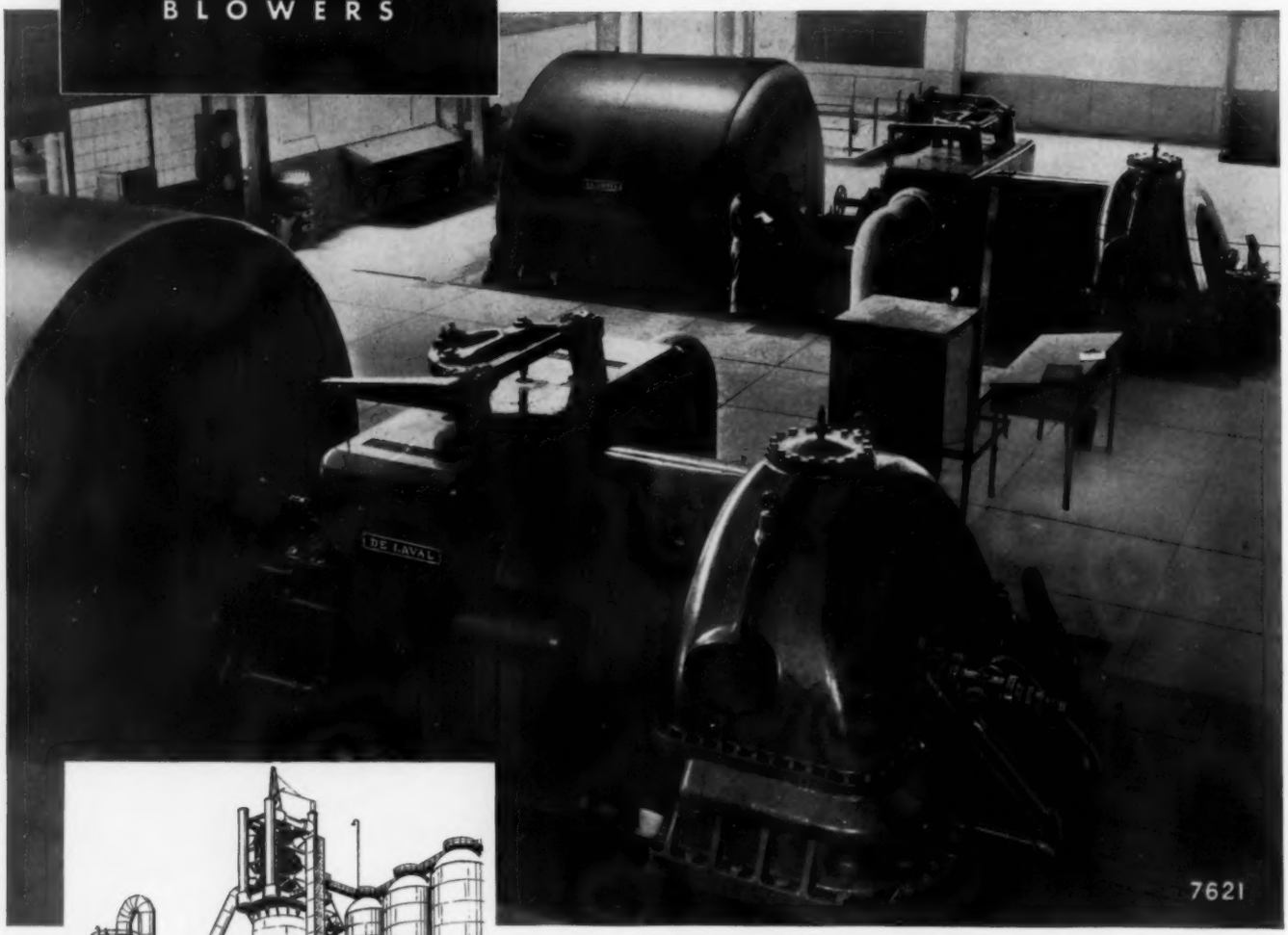
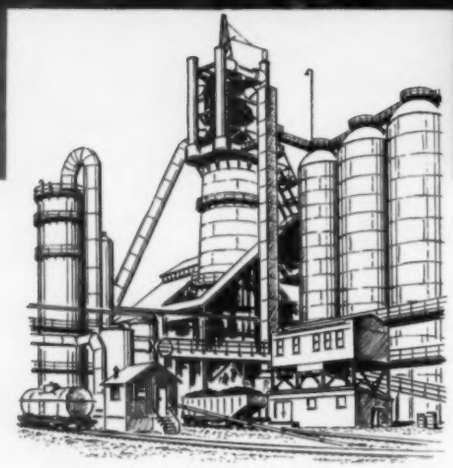
STEEL MILL
BLOWERS

designed for giant furnaces





These twin De Laval blowers, on the job in a leading mid-western steel mill, are among the largest ever built. Each is a five-stage unit with a rated capacity to deliver 121,000 cfm of air at 35 psig discharge pressure. Each is driven by a 15,220 hp, 2,500 rpm De Laval 16-stage steam turbine operating under steam conditions of 400 psig, 750 F with 28 in. vac.

The total weight of each De Laval turbine and blower is over 167 tons; the blower alone is over 212,000 lbs. Shafts of the turbine and blower were made large and heavy to meet the wide range of varying speed conditions required in blast furnace service. Outside diameter of the blower casing is 12 ft. and it is divided horizontally in the plane of the shaft. This permits raising the upper half of the casing for easy access to all interior parts. • For a quarter of a century, De Laval has pioneered in advanced blower engineering designs and practices. De Laval builds single and multi-stage centrifugal blowers and compressors for service in steel, gas and coke plants. Discuss your specific applications with a De Laval Sales Engineer.

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DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey

DL-234

A STUDY of ALUMINUM SHEET ANNEALING

Fabricators of aluminum sheet products that require severe forming or deep drawing are familiar with the drawbacks of using material with irregular grain structure and/or a heterogeneous hardness pattern. Excessive grain size appears in the form of "orange peel" effect, and when directional properties are not closely controlled, "earing" is apt to occur.

The "orange peel" detracts from the product finish and requires costly secondary operations to remove, and above normal "earing" means excessive scrap with frequently an extra trimming operation.

Photograph illustrates seven types and shapes of drawn aluminum alloy cups exhibiting varying degrees of ears.

SCOVILL MANUFACTURING CO. LEADS THE WAY

Two years ago the Scovill Manufacturing Co., Waterbury, Conn., a producer of aluminum sheet since 1889, in anticipation of future requirements of industry, set into operation an aluminum annealing system that was the result of years of planning and experimentation. They wanted to provide a sheet with exceptional uniformity of physical properties and grain structure with an especially fine finish. And, they wanted to offer this strip in extra-long coils.

Scovill studied all existing methods of annealing and selected the Lee Wilson Bell Type Radiant Fired "O" Tube Furnace with Controlled Nitrogen Atmosphere as the equipment best suited to do the job.

Photograph illustrates varying degrees of "orange peel" effect.

In 1952 the installation was completed. It comprises two furnaces and six bases. Each furnace is equipped with 12 Lee Wilson "O" tubes with a total input of 3,600,000 BTU per hour at maximum fire rate. To get the most effective heat transfer possible, Lee Wilson convector plates are placed between stacked coils of the charge.

WILSON FURNACES ARE FAST

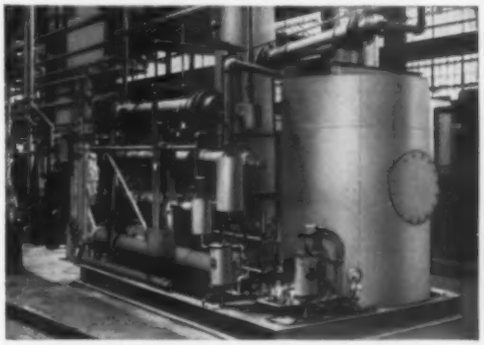
A study of coil size requirements resulted in a base which can load three stacks of 36" diameter coils with a piling height of approximately 60" net per load. In determining piling height, deformation and sticking of bottom coil edges were considered. Large coil requirements were considered in designing furnace diameters. With full charges of coils large enough to utilize convector plates, production per furnace with three bases is about 2500 lbs. per hour, or 5000 lbs. per hour for the installation.

NITROGEN ATMOSPHERE USED

For the first time in the history of aluminum annealing, nitrogen atmosphere is used. By keeping oxygen away from the aluminum during the annealing cycle, the formation of surface oxides is eliminated. The natural aluminum finish is retained.

What have Scovill and its customers to say about this controlled annealing? "We are getting," say Scovill officials, "sheet with controlled grain sizes, tempers, directional properties and dimensions far closer than once was thought possible. The control we can exert over the charge with the bell type furnace and regulated high input firing tubes in an oxygen-free atmosphere enables us to produce sheet of exacting grain structure and hardness with perfect uniformity throughout the entire charge."

Scovill has received glowing commendations from its customers which substantiate the above statement. Scovill calls this "new" aluminum sheet Truspec.



Generator which produces dry nitrogen atmosphere for the annealing process. A product of Gas Atmospheres, Inc., a Lee Wilson enterprise.

GET THE COMPLETE STORY

If you are in the business of producing aluminum or any non-ferrous or ferrous metal in strip, sheet, coil or wire and rod forms, check first with a Lee Wilson engineer before you buy annealing equipment.

Typical full charge of 36" diameter aluminum coils with convector plates in place.

Comprehensive view of the Scovill annealing installation of Lee Wilson bell type furnaces of the high convection type.

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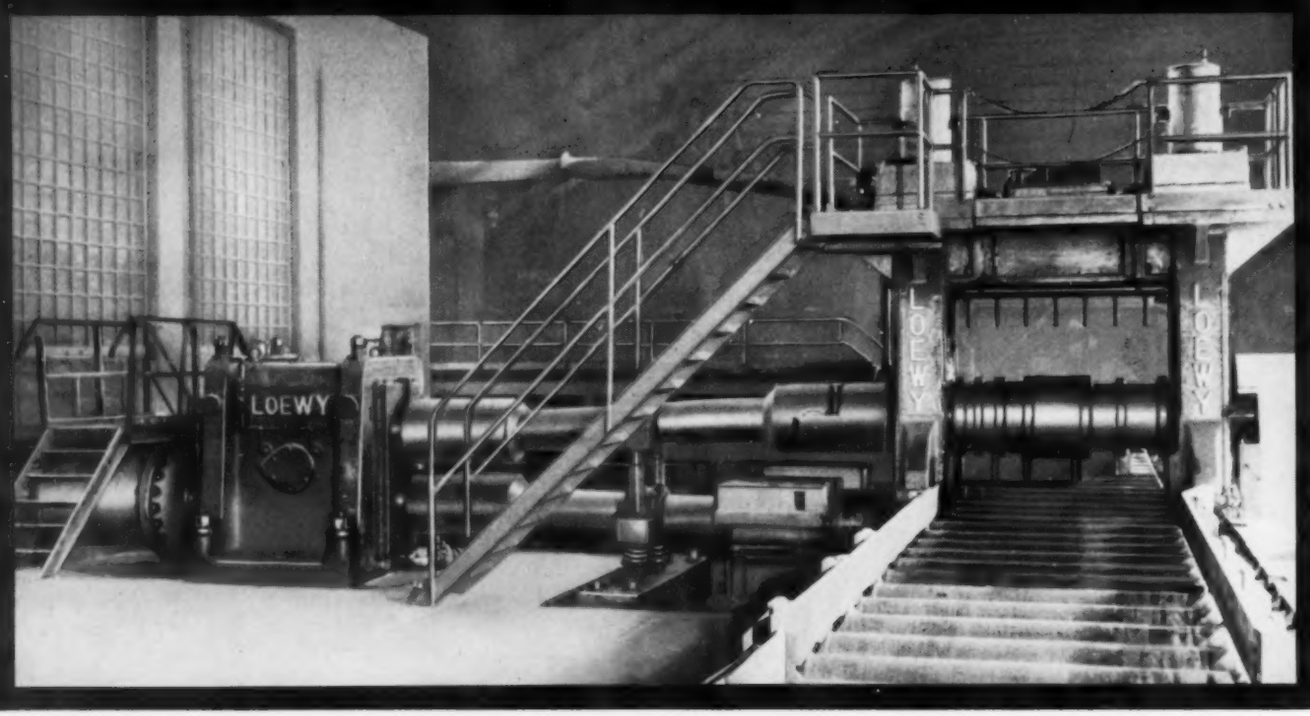
26" Three-high Blooming Mill Stand, part of a complete Blooming, Slabbing, Structural, Wire Rod and Strip Mill.



26" Two-high Blooming Mill, part of a complete Blooming, Slabbing, Structural and Strip Mill Installation.

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3. **CONCENTRIC ROLLS** have smooth surfaces and rounded edges. Machine-made, continuous welds prevent entrance of dirt and moisture.
4. **OUTER SHELL COUNTERBORES AND COUNTERBORES AND JOURNAL** of the heavy 3/16" thick wall bearing retainer tubes with the press fits of the roll head assures hop-free rotation.
5. **STRONG, RIGID FRAMES** support rolls in perfect alignment. Rolls are securely held in place but can be easily removed for inspection and service.
6. **GROOVED HEX NUTS** lock into malleable brackets, creating truss effect—prevent shaft rotation and bracket spreading under both vertical and impact loads.

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for prompt deliveries over wider area

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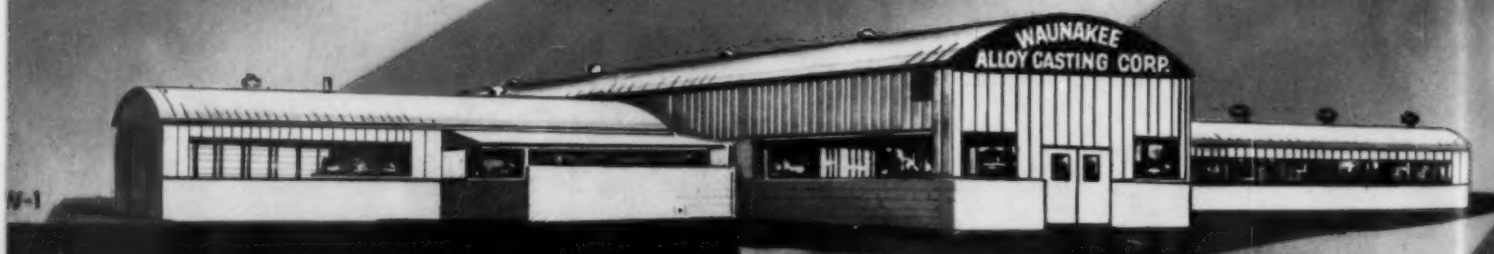
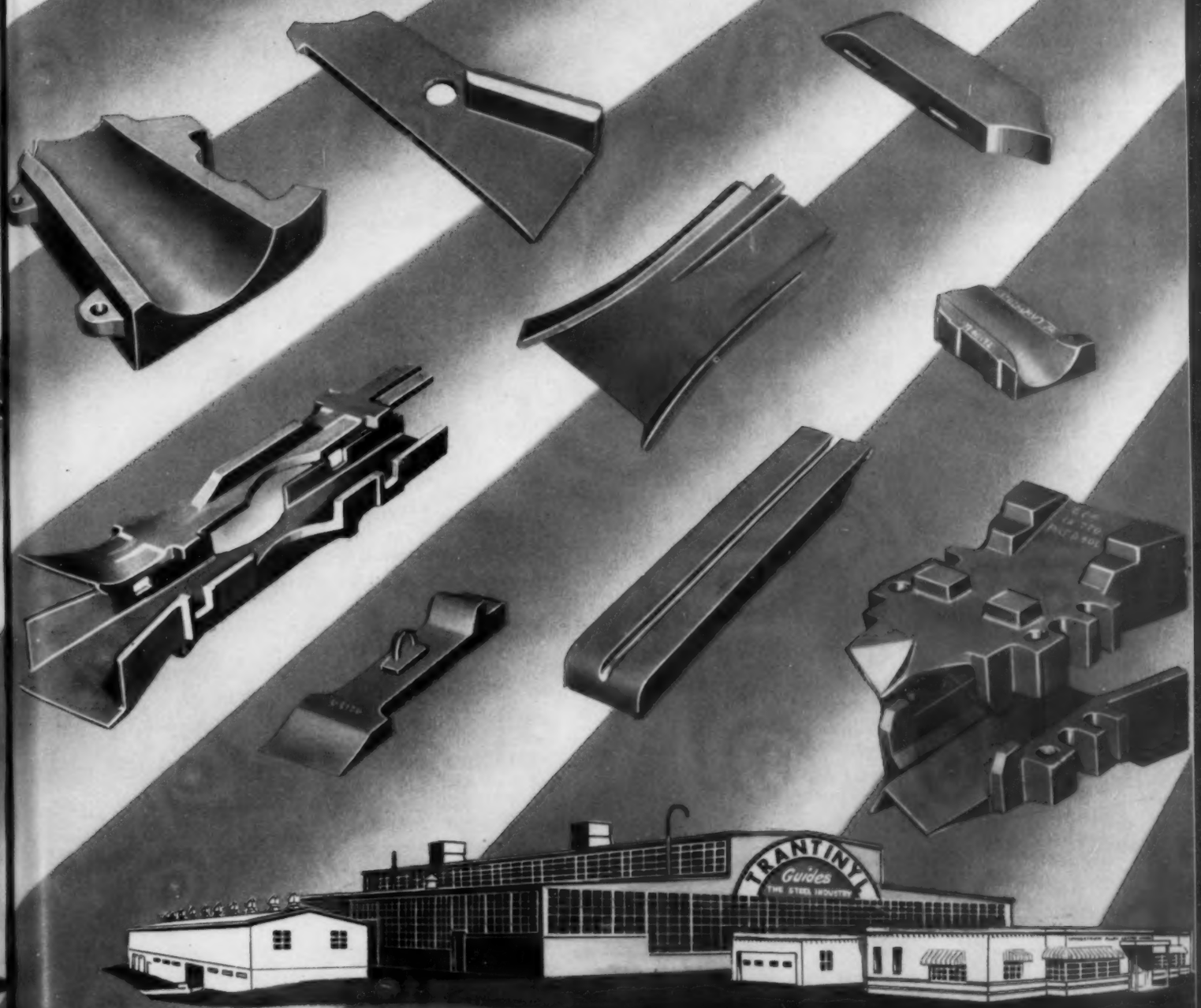
"TRANTINYL" NO. 1 CAST TO SHAPE



WAUNAKEE ALLOY CASTING CORPORATION
WAUNAKEE, WISCONSIN

NOW-2 **PLANTS TO SERVE YOU**

TRANTINYL ...the alloy that GUIDES THE STEEL INDUSTRY



... CONTACT THE PLANT NEAREST YOU

YOUNGSTOWN ALLOY CASTING CORPORATION
YOUNGSTOWN, OHIO

Compact panel providing L&N all-electric Integrated Control for two-zone billet heating furnace in National Tube Division skelp mill at Fairless Works. Its job: close regulation of temperature, fuel-air ratio and furnace pressure in both the heating and soaking zones of the furnace.

NATIONAL TUBE REGULATES BILLET FURNACE WITH

L+N Integrated Control

● All Leeds & Northrup Integrated Control panels are factory-engineered for the specific job . . . yet employ standardized instruments recognized for their simplicity, accuracy and flexibility.

For example, the controllers which are keeping tab on temperature, on fuel-air ratio and on gas pressure at this National Tube furnace all use the same stable, sensitive proportional controlling action. Result: close adjustment for optimum control with proportional band, automatic reset and rate action readily tuned by the operator to suit the individual furnace characteristics.

All L&N electric control units rely—for sensitivity in control detection and accuracy in control correction—on the well-established principle of the null-balance measuring circuit.

L&N integrated control instruments are easy to adjust . . . easy to maintain. They can be mounted on a panel to suit your individual requirements. Installation at your plant site is carried out quickly and economically.

End result, of course, is a furnace control system which steps up operating efficiency . . . provides better heating of the work . . . economizes on fuel . . . and cuts maintenance costs.

This same combination of L&N instruments and specialized engineering service is available for the solution of your furnace control problems. Just contact your nearest Leeds & Northrup representative about Integrated Control or, if you prefer, write us at 4942 Stenton Ave., Philadelphia 44, Pa., outlining your problem.

LEEDS *instruments* **NORTHRUP** *automatic controls • furnaces*

Jrl. Ad N-33-640(8)

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents issued cover period February 9, 1954 through March 2, 1954 . . . .

PRODUCTION OF LOW-PHOSPHORUS, LOW-NITROGEN STEELS

▲ Low-phosphorus steels which are also low in nitrogen may be produced by a method described by Michael Tenenbaum in U. S. 2,668,757. The patent was issued Feb. 9, 1954, and assigned to Inland Steel Co.

The apparatus used is shown in Figures 1 and 2, the former being a sectional view and the latter a plan view. Molten pig iron is introduced into the vessel 10 through the door 15 along with a basic slag-forming material, such as limestone, and an iron oxide-bearing material such as iron ore, sinter, or mill scale. In order to avoid excessive cooling of the molten iron charged, it is desirable that the refractory lining 13 be preheated to an elevated temperature by means

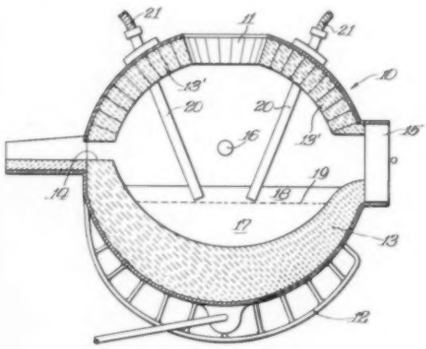


Figure 1

of the burners 16, or that the vessel be charged while still hot from a previous heat.

Immediately following the charging of the molten metal to the vessel 10, an oxidizing gas containing a relatively high concentration of free oxygen is introduced through the lances 20. The positions of the lances 20 are adjusted to inject the oxidizing gas at the metal surface, to effect direct contact of free oxygen with the molten metal and thereby obtain rapid transfer of oxygen to the metal.

The heat requirements of the process are supplied substantially entirely by the exothermic heat of reaction evolved during the refining of the molten iron.

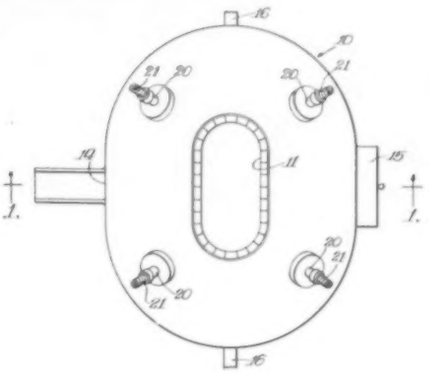


Figure 2

As the molten iron is contacted with oxygen, a large part of the silicon, manganese, and phosphorus in the iron is rapidly oxidized to form the corresponding oxides together with simultaneous oxidation of a small but definite portion of the carbon. The oxides of silicon, manganese, phosphorus, and iron together with lime obtained from the charged limestone are then incorporated in an oxidized slag containing most of the phosphorus and substantially all of the silicon and manganese. If desired, most of the slag may be withdrawn at this point, by tilting the vessel 10 to discharge the slag through the tap hole 14.

A large proportion of the charged limestone rises almost immediately to the surface of the molten metal. At first, the limestone is largely uncalcined and unpenetrated by slag constituents, and the oxides of silicon, manganese, and phosphorus formed as described above, together with iron oxide and lime form the early slag. However, turbulent intermixing of the slag, iron oxide, and metal phases is obtained promptly, and localized high temperatures and a highly oxidizing atmosphere are developed upon the introduction of gaseous oxygen to the bath with the result that rapid calcination of the limestone and rapid solution of the resultant lime in the slag are realized. The amount of lime that is dissolved in the early stage of the process may be regulated merely by charging controlled amounts of limestone. In this way the fluidity of the early slag as well as its phosphorus content can also be regulated.

An important characteristic of the process is the fact that it permits the early development of a slag having a ratio of weight per cent lime to weight per cent silica of about 2.0. In the conventional basic open hearth process, the development of a slag of this degree of basicity is not ordinarily possible before a substantial degree of carbon elimination has taken place, for example, not before the carbon content of the metal has been reduced below about 1.25 per cent. In the present process, on the other hand, it is possible to effect rapid and substantial entry of phosphorus into the slag and at the same time obtain a slag having a sufficient degree of basicity before the carbon content of the metal is reduced to a low level, in most instances before carbon falls

below about 2 per cent, to retain practically all of the eliminated phosphorus throughout the balance of the refining period. In this manner reversion of phosphorus from the slag to the metal is minimized.

The rapid formation of such a slag is attributable (1) to the greater availability of the limestone to the slag phase as a result of the physical mixing effect and turbulence created in the bath, and (2) to the more rapid rate of solution of lime in the slag phase as a result of the localized high temperature and highly oxidizing atmosphere which are developed upon direct contacting of free oxygen with the metal in the manner described. In addition, the combined effects of turbulence in the bath and the local high temperature conditions tend to minimize the formation of and to otherwise overcome the detrimental effects of dicalcium silicate shell formation around the individual lumps of limestone, thereby further facilitating the rapid solution of lime in the slag phase.

The desired turbulent intermixing of the slag, iron oxide, and metal phases is obtained as the result of two interrelated effects. First of all, the injection of oxygen-containing gas downwardly below the surface of the bath causes a certain degree of local agitation due to the mechanical effect of the gas injection. However, the injection of oxygen in this manner also induces prompt carbon-oxygen reactions in the bath with the resultant evolution of gaseous oxidation products in abundant amounts. It is characteristic of the carbon-oxygen reaction that carbon oxide gas forms at the sides and at the bottom of the bath, and the gases escape upwardly throughout the bath so that there is widespread turbulence and intermixing, thereby greatly enhancing the immediate mechanical turbulence and agitation which is a direct result of the mode of oxygen injection.

The refining reaction rates are fast and the refining period is relatively short, e.g. from about ½ to about 3 hours as compared with the much longer period of time required to produce a comparable product by the conventional open hearth process.

Other advantages of the process are the ability to remove phosphorus while retaining considerable carbon in the steel, the effective degree of removal of sulphur, and reduced corrosion of the refractory lining.

Steel scrap may be added whenever the temperature is sufficiently high.

Several examples are given in the patent. Figure 3 shows an example of the results.

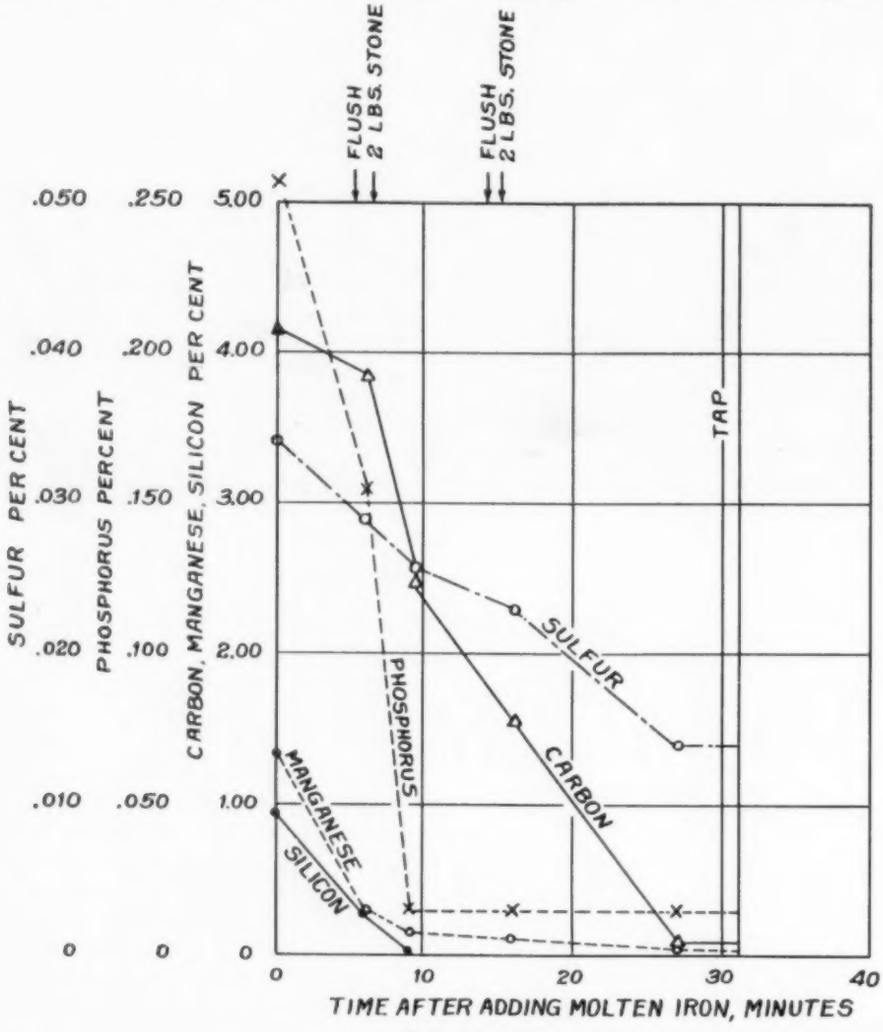


Figure 3

METHOD OF FLUIDIZING SLAG IN STEEL MANUFACTURE

Solution of lime particles floating in the slag in an open hearth or an electric furnace is considerably retarded by the formation of a high-melting coating of dicalcium silicate on the particles.

Dicalcium ferrite reacts with the coating of dicalcium silicate, and by reason of the law of eutectics, it dissolves the coating of dicalcium silicate from around the lumps of lime. In normal practice, waiting for the oxidizing reaction which forms dicalcium ferrite is too slow, so the furnace operator commonly resorts to the use of fluorspar additions to speed up the solubilizing reaction of lime. The fluorspar, because of its lower melting point (1360 C) and the law of eutectics, and its other properties, speeds up the fluxing and fluidizing process of the lime. However, fluorspar in some cases is detrimental to the steel quality, unless precisely used, by tending to increase the concentration of FeO in the slag.

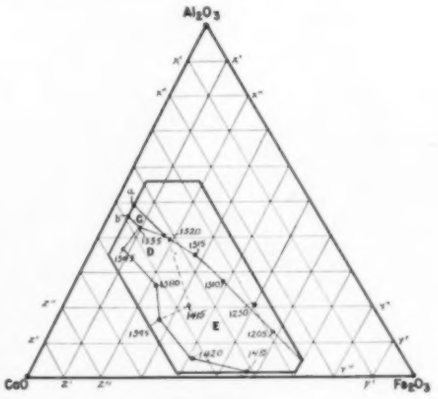


Figure 4

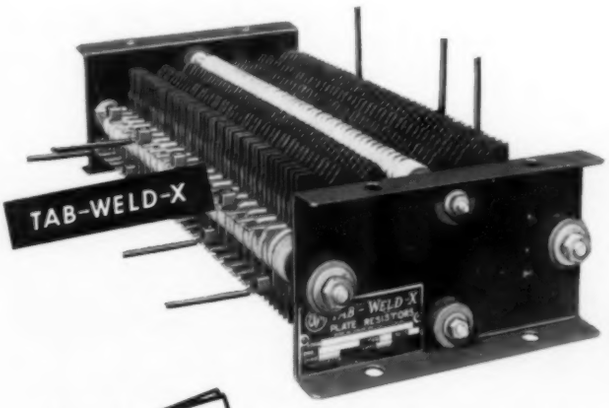
A patent of James J. Bowden, originally issued May 27, 1952 as U. S. 2,597,581, has now been re-issued in a somewhat modified form as Re 23,778. The date of re-issue was Feb-

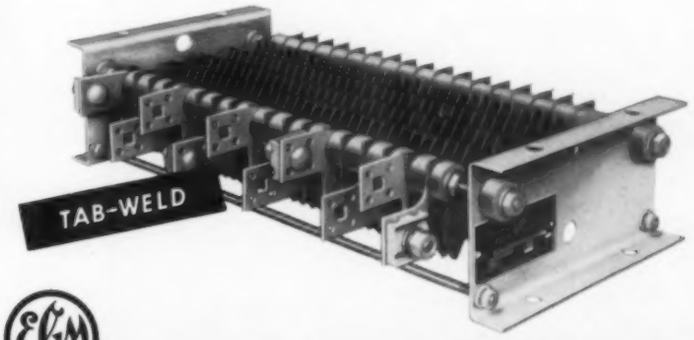
low priced yet...it includes Preventive Maintenance

"F. O. B." *(FREE-OF-BURNING)*

Resistors get little attention, because they are usually mounted overhead or in similar hard-to-reach locations. Clamping-nut pressure slackens under alternate heating and cooling. Formerly, under the reduced pressure, OHMIC value changed, burning occurred and often was *not* noticed until damage took its toll.

But — note how resistor troubles are now eliminated in the EC&M TAB-WELD design! The current-carrying path is continuous — and is *independent* of end clamping-nut pressure. Convenient tap - plates simplify tap-shifting—make possible small adjustments in resistance value, because plates are closely spaced. Also, these alloy-steel resistors are corrosion-resisting—and have negligible resistance-change between cold and maximum working temperatures.



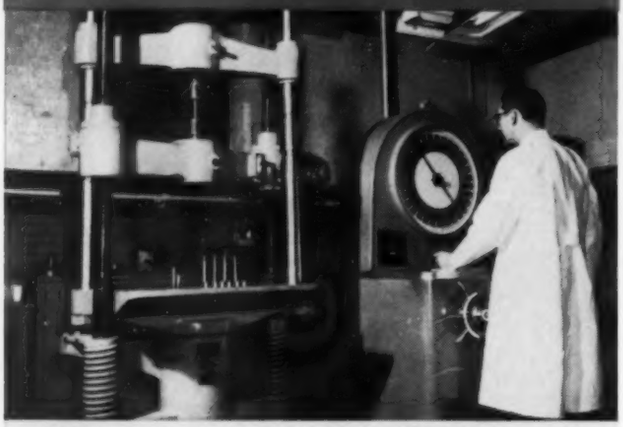


SPECIFY BULLETIN 942 EC&M Welded Plate Resistors

E C & M

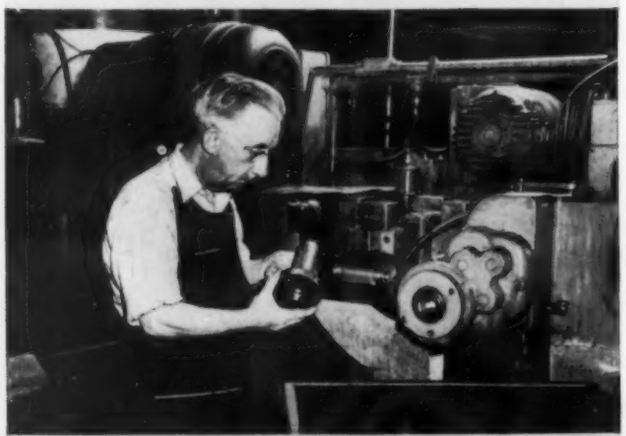
THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

CROUSE-HINDS rigid quality control *assures long-lasting products ...* CONDULET* records prove it!



Making a tensile strength test of a Feraloy bar in the Mechanical Laboratory. Constant testing insures uniform quality.

A hydrostatic test of a Type EPC explosion-proof Condulet. It must withstand a pressure 4 times as great as an internal explosion.



Guaging the threads of an Obround Condulet in the factory. Crouse-Hinds quality control follows through to the finished product.

The first CONDULETS, introduced by Crouse-Hinds in 1905, were so well designed and so carefully manufactured that many of the early installations are still in use.... still giving dependable service after more than forty years. This record proves that where quality counts, you can count on CONDULETS!

Crouse-Hinds high standard of quality has always been controlled by careful checking and testing of both raw materials and the finished product. The CONDULET line has expanded from a few items to more than 15,000 types and sizes and the testing laboratories have kept pace with this development. They contain the latest and most modern testing equipment.

Laboratory testing is only part of Crouse-Hinds system of rigid quality control. Factory inspection is equally important. Together, they assure a superior product that will serve you better . . . and last longer!

Always specify CONDULETS.

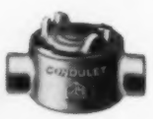
***CONDULETS are made only by CROUSE-HINDS**

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

OFFICES Amarillo — Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland
Dallas — Denver — Detroit — Houston — Indianapolis — Kansas City — Los Angeles — Memphis
Milwaukee — New Orleans — New York — Philadelphia — Pittsburgh — Portland, Ore.
San Francisco — Seattle — St. Louis — St. Paul — Tulsa — Washington
RESIDENT REPRESENTATIVES Albany — Atlanta — Baltimore — Charlotte — Chattanooga
Corpus Christi — Reading, Pa. — Richmond, Va. — Shreveport
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

Type LB
Obround Condulet

Type EVA Explosion-Proof
Lighting Fixture



Type GUAC Explosion-Proof
Junction Condulet

Type ARE
Plug Receptacle

Type FSC Tumbler
Switch Condulet

CONDULET
First in the field
STANDARD OF QUALITY

A Nationwide Distribution Through Electrical Distributors

AIRPORT LIGHTING · FLOODLIGHTS · CONDULETS · TRAFFIC SIGNALS

ruary 9, 1954. In this patent, slags are fluidized by adding a mineral having certain percentages of CaO, Al_2O_3, and Fe_2O_3. The compositions used fall within the areas E, D, and C of Figure 4, in the order of preference stated. The addition of a mineral of this composition dissolves the high-melting dicalcium silicates surrounding the lime particles.

METAL PIPE HAVING A ROLLED THREAD

Lengths of thin-walled steel tubing are fastened together end-to-end to make long tubes for various purposes, as for example, so-called shot hole casing. Each length or section is somewhat expanded at one end so that it will telescope with the unexpanded opposite end of a similar section, and threads are rolled into the telescoping ends so that they may be screwed together. The thread rolling operation is rapid and economical and for relatively thin-walled pipe and pipe of sufficient ductility is far less costly than cutting threads by the conventional method; moreover, a stronger and otherwise superior product is produced.

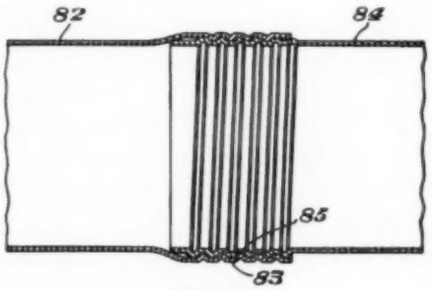


Figure 5

In U. S. 2,669,469, issued Feb. 16, 1954, to Harry J. Finch, and assigned to Jones & Laughlin Steel Corp., a uniform thread is produced by causing a flow of metal while avoiding any substantial shearing action. The pipe is rotated about its axis and during the rotation, the pipe is engaged internally and externally so as to squeeze the metal and cause it to flow without shearing. In this way, a thread is rolled into the pipe wall, the side walls of which thread are substantially parallel to each other. Figure 5 shows at the left the shape of the dies and in cross-section at the right the shape of the threads formed. Figure 6 shows the pipe joint made by threading two pipes together.

Details are given in the patent specification.

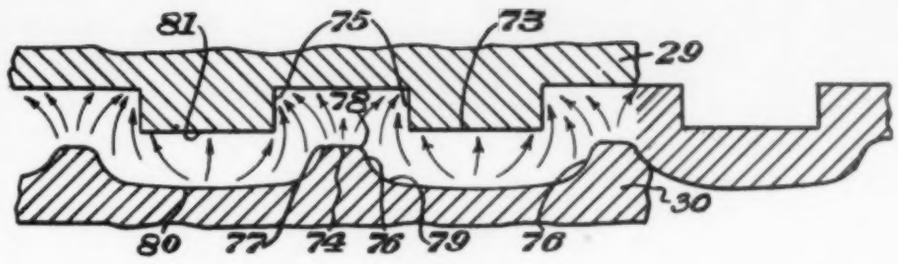


Figure 6

PRODUCTION OF BASIC BESSEMER STEEL LOW IN NITROGEN

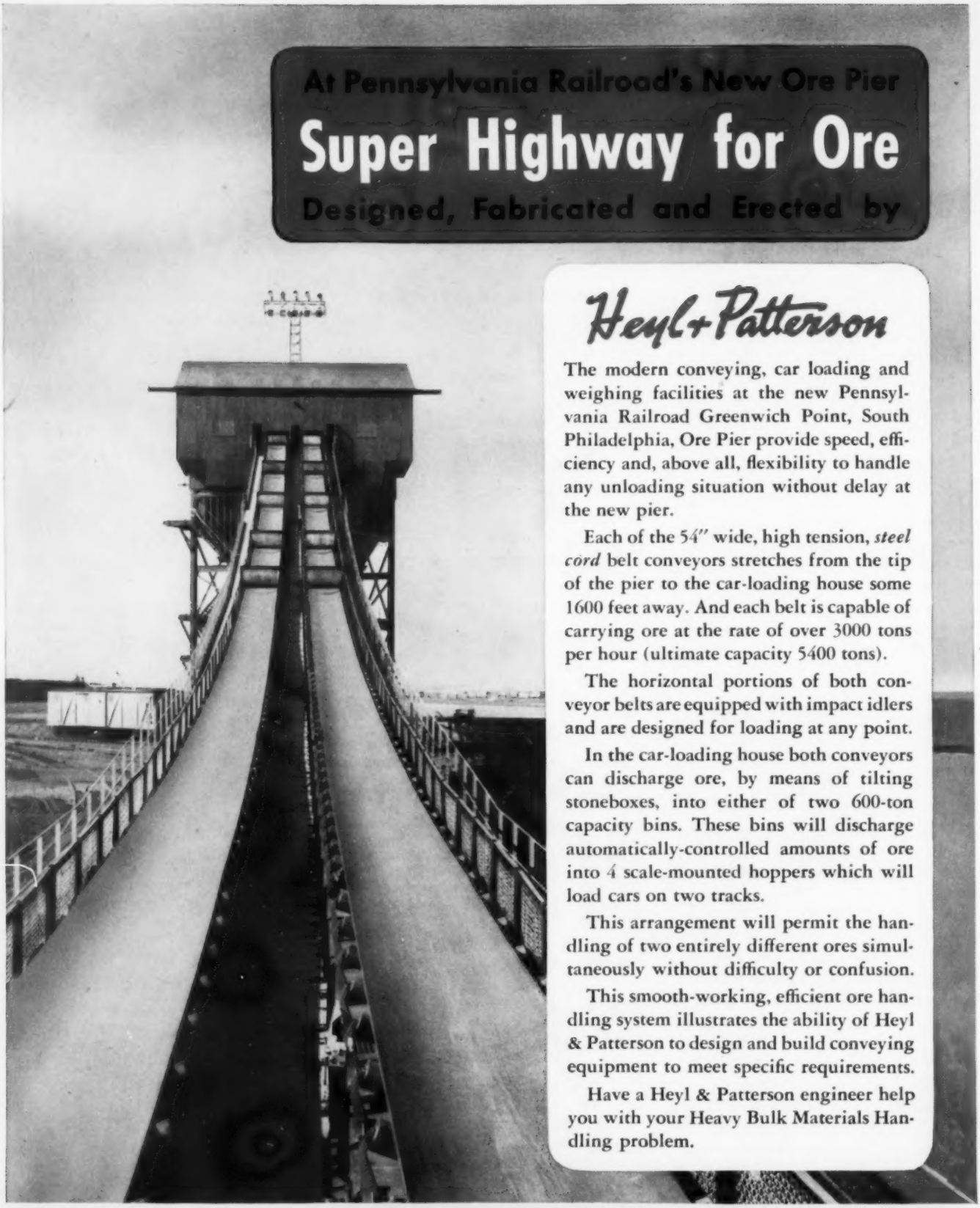
In U. S. 2,671,018, issued March 2, 1954, Rudolf F. Graef describes a method for minimizing the absorption of nitrogen during the dephosphorization period in a basic bessemer converter. In essence, it involves adding powdered lime to the blast. The assignee of the patent is Huttenwerk Oberhausen A. G.

REFINING OF STEEL FOR LOW SULPHUR

According to Camille Soisson, in U. S. 2,670,283, issued Feb. 23, 1954, low sulphur contents can be obtained when refining steel in a converter by adding aluminum to the molten steel in the converter. The vigorous stirring and the heat given off by the oxidation of the aluminum make it possible to carry out a very thorough refining in less time than normal.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,668,336	2/ 9/54	Hot top for ingot molds	Republic Steel Corp.
2,668,701	2/ 9/54	Control system for continuous heating strip metal	Selas Corp. of America
2,669,031	2/16/54	Drying oven for wire	United States Steel Corp.
2,669,032	2/16/54	Apparatus for cooling hot agglomerated material from a sintering apparatus	Metallgesellschaft A.G.
2,669,139	2/16/54	Apparatus for rolling threads into metal pipe	Jones & Laughlin Steel Corp.
2,669,140	2/16/54	Material turning device for a bar being rolled or shaped	Erwin Loewy
2,669,355	2/16/54	Method for flotation of iron oxide minerals	United States Steel Corp.
2,669,442	2/16/54	Apparatus for annealing strip steel	Crown Cork & Seal Co., Inc.
2,669,445	2/16/54	Heat-treating apparatus	Holcroft & Co.
2,669,446	2/16/54	Cupola furnace	Robert Doat
2,669,484	2/16/54	Burner unit for an open hearth furnace	Lukens Steel Co.
2,669,493	2/16/54	Thrust bearing for rolling mill rolls	United States Steel Corp.
2,669,545	2/16/54	Methods of preparing flotation agents	United States Steel Corp.
2,669,593	2/16/54	Aspirator thermocouple mounting for measuring the temperature of hot gases	United States Steel Corp.
2,669,863	2/23/54	Apparatus for measuring the melting point of fusible materials	American Instrument Co., Inc.
2,669,892	2/23/54	Rolling mill	Morgan Construction Co.
2,670,088	2/23/54	Charging apparatus for a cupola	Modern Equipment Co.
2,670,510	3/ 2/54	Apparatus for conveying metals to centrifugal casting molds	Campbell, Wyant & Cannon Foundry Co.
2,670,698	3/ 2/54	Furnace roof for metallurgical furnaces	Republic Steel Corp.
2,670,780	3/ 2/54	Cross rolling machine for straightening tubular or round stock	The Mackintosh-Hemphill Co., Inc.
2,670,781	3/ 2/54	Straightening mechanism for round bars	Gustaf E. Brofelth
2,670,796	3/ 2/54	Apparatus for cutting strip	United States Steel Corp.
2,670,818	3/ 2/54	Method of erecting cupola structures	Maschinenfabrik Esslingen A. G.
2,670,850	3/ 2/54	Centrifugal ore dryer	Frank R. Wassberg
2,670,946	3/ 2/54	Apparatus for magnetic roasting	Pickands Mather & Co.
2,670,947	3/ 2/54	Apparatus for sintering machines	Duncan Foundry & Machine Works, Inc.
2,670,985	3/ 2/54	Sheet lifting mechanism	United States Steel Corp.
2,671,008	3/ 2/54	Separation of acid gases from coke oven gases	Koppers Co.
2,671,017	3/ 2/54	Method of charging a blast furnace	Reserve Mining Co.
2,671,038	3/ 2/54	Method for inhibiting roll pickup in continuous annealing of steel strip	United States Steel Corp.
2,671,050	3/ 2/54	Stainless steel alloy	Standard Oil Co. (Ind.)



At Pennsylvania Railroad's New Ore Pier

Super Highway for Ore

Designed, Fabricated and Erected by

Heyl+Patterson

The modern conveying, car loading and weighing facilities at the new Pennsylvania Railroad Greenwich Point, South Philadelphia, Ore Pier provide speed, efficiency and, above all, flexibility to handle any unloading situation without delay at the new pier.

Each of the 54" wide, high tension, *steel cord* belt conveyors stretches from the tip of the pier to the car-loading house some 1600 feet away. And each belt is capable of carrying ore at the rate of over 3000 tons per hour (ultimate capacity 5400 tons).

The horizontal portions of both conveyor belts are equipped with impact idlers and are designed for loading at any point.

In the car-loading house both conveyors can discharge ore, by means of tilting stoneboxes, into either of two 600-ton capacity bins. These bins will discharge automatically-controlled amounts of ore into 4 scale-mounted hoppers which will load cars on two tracks.

This arrangement will permit the handling of two entirely different ores simultaneously without difficulty or confusion.

This smooth-working, efficient ore handling system illustrates the ability of Heyl & Patterson to design and build conveying equipment to meet specific requirements.

Have a Heyl & Patterson engineer help you with your Heavy Bulk Materials Handling problem.

High Lift-Turnover-Rotary Railroad Car Dumpers
Boat Loaders and Unloaders
Ore Bridges
Coal Handling Equipment
Pig Iron Casting Machines
Cyclone Thickeners
Thorsten Coal Samplers
Car Hauls and Boat Movers
Coal Crushers
Bradford Breakers

Heyl+Patterson, Inc.

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25

TWENTY-FIFTH ANNIVERSARY

The WEAN

ENGINEERING
COMPANY · INC.
WARREN, OHIO

The WEAN ENGINEERING COMPANY, INC.

Twenty-five years ago — on June 28, 1929 — incorporation papers for The Wean Engineering Company, Inc. were taken out in Warren, Ohio. At that time the company consisted of a rented room in a bank building, a stenographer, a couple of desks, a telephone and many ideas for bettering the processes of steel finishing.

Today, The Wean Engineering Company, Inc. is housed in modern quarters, employing several hundred people. The organization is composed of what is acknowledged to be one of the finest groups of planners and equipment designers that work on steel mill facilities today. The original ideas have given birth to much of the equipment and methods accepted today as standard practice.

The following pages show a cross section of Wean sheet, tin and strip mill installations working in the mills of virtually every country where steel is produced.

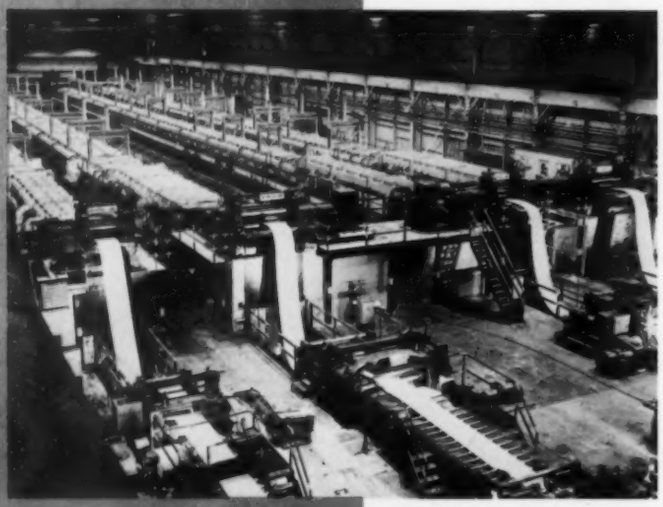
Wean
EQUIPMENT
CORPORATION

In 1941, Wean acquired the controlling interest in the Broden Construction Company of Cleveland. In 1947, this concern was reorganized and renamed the Wean Equipment Corporation and has specialized in the design and manufacture of high speed slitting and shearing lines; zinc, babbit, etc., coating lines for the steel processing industry, wire making and fence fabricating machinery and special equipment such as pictured on page seven.

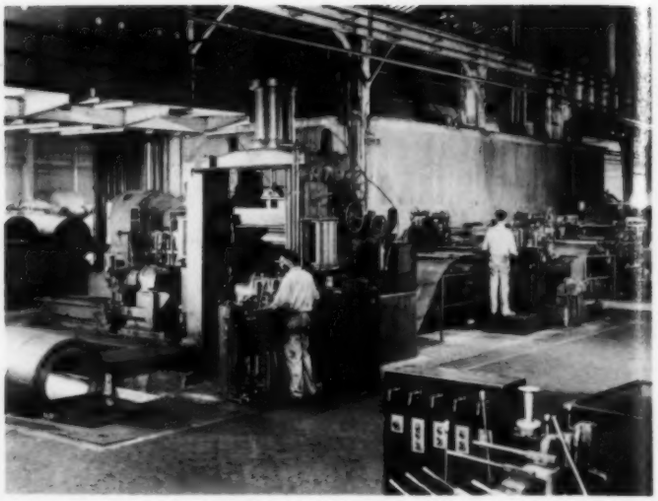
WEAN
MANUFACTURING
COMPANY

The shortage of storage and fabricating facilities of the late 40's prompted the Wean Engineering Company to set up its own plant for storing parts and assembling equipment. Thus, in 1949 the Wean Manufacturing Company in Warren, Ohio, became an important part of the producing facilities for the Wean companies.

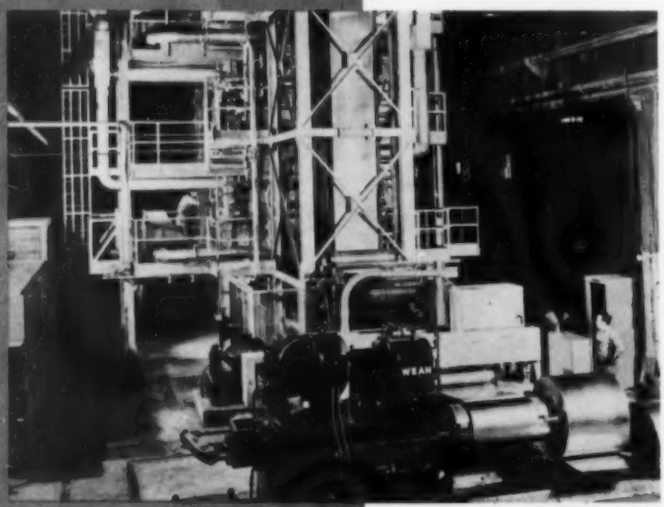
WEAN ENGINEERING COMPANY *Installations*



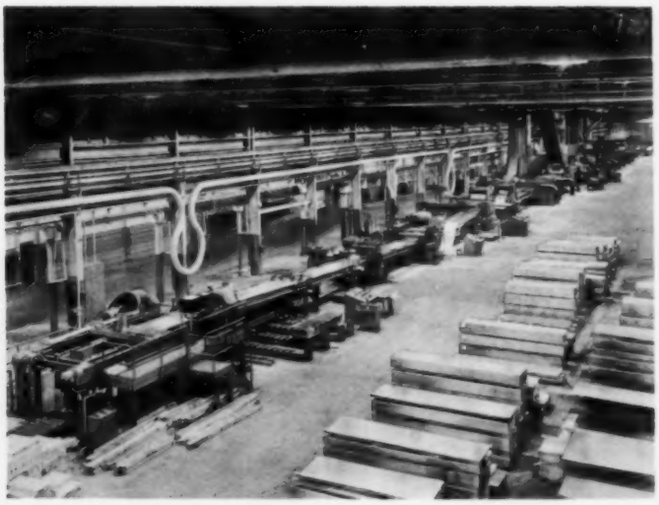
Four Wean Strip Pickle Lines



Hot Strip Shearing Line



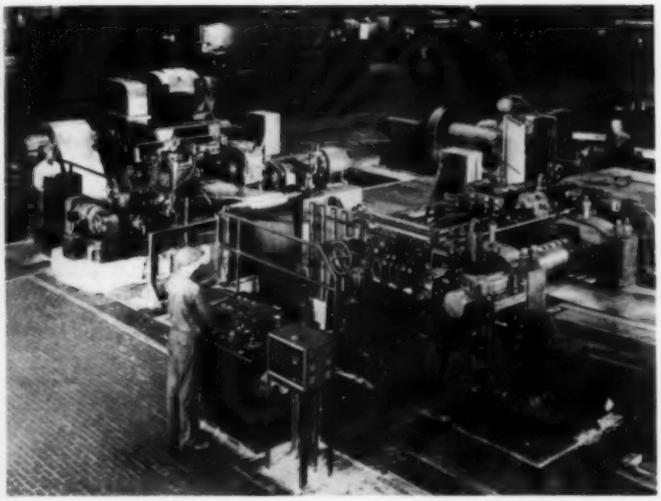
Continuous Strip Annealing Equipment



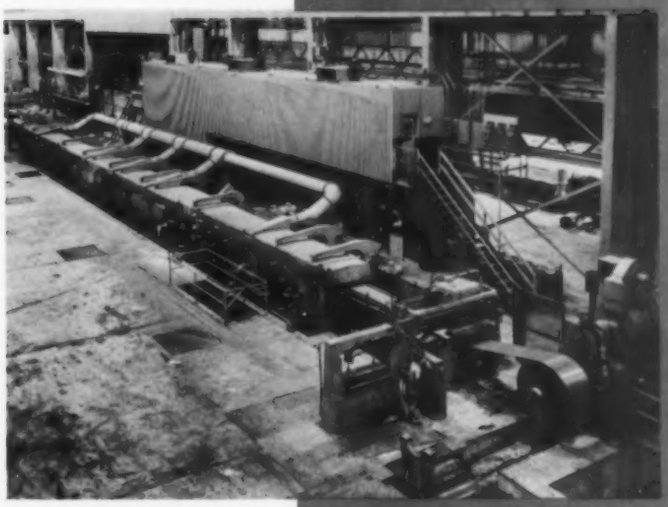
Continuous Strip Galvanizing Line

In the quarter century that the Wean Engineering Company, Inc. has been a part of the American business scene there has actually been in progress a second industrial revolution.

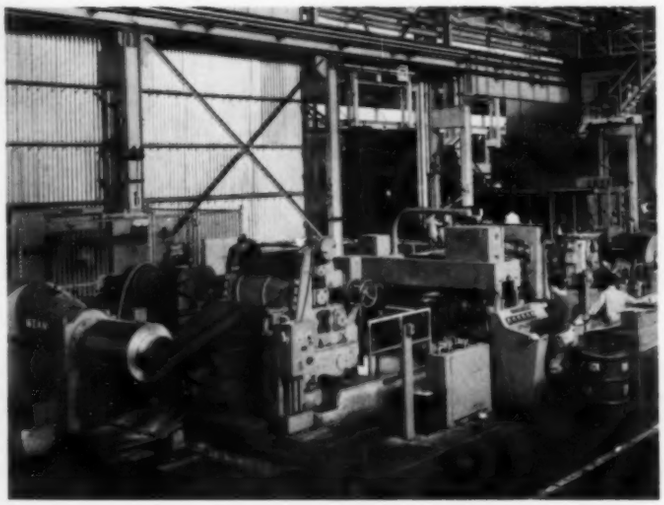
Methods employed to produce and process steel in the late twenties and early thirties are no longer economical. The great demand for the various steel products, both for military and civilian purposes, has forced steel makers into demanding equipment that would produce steel faster and faster and, at the same time, develop new steels and improve old ones to make them more compatible with modern fabrication methods. To do this and in an economical fashion, steelmaking began a long process of redevelopment. Wide strip steel



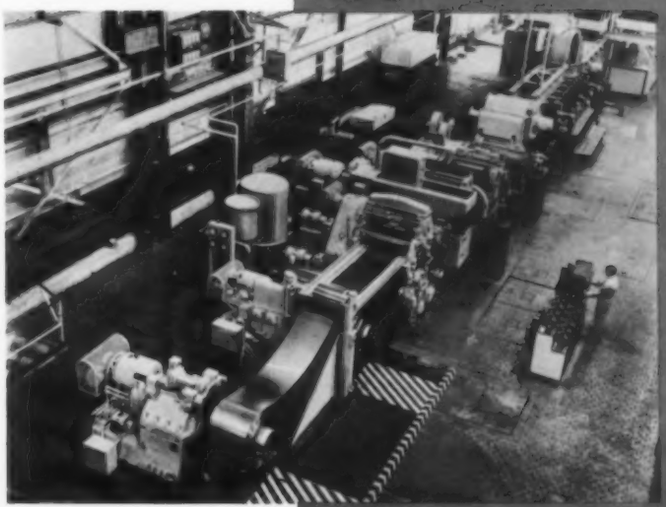
Cold Strip Shearing Line



Electrolytic Cleaning Line



Coil Preparation Line



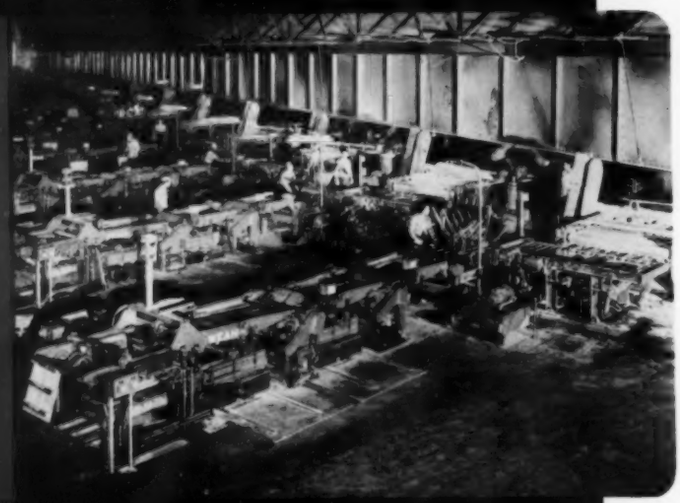
Electrolytic Tinning Line

replaced sheets. Larger coils that would mean longer production runs became desirable. Continuous processing for annealing, coating, edging and coiling was developed and keeps the steel on the go in constantly increasing volume and at even greater speeds.

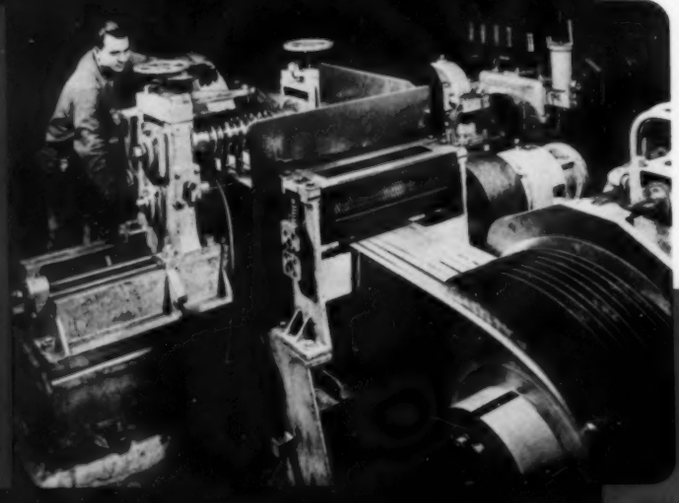
During the past 25 years, Wean engineers have played an important role in this revolution. It was these engineers who developed much of the continuous processing equipment and it was these engineers who championed high speed slitting and shearing systems. In fact, wherever you see a modern sheet, tin or strip mill facility in operation, chances are a good part of the working equipment carries the Wean Engineering nameplate.

Continued →

Electrolytic Tinning Horizontal Plater



Hot Dip Tinning Equipment

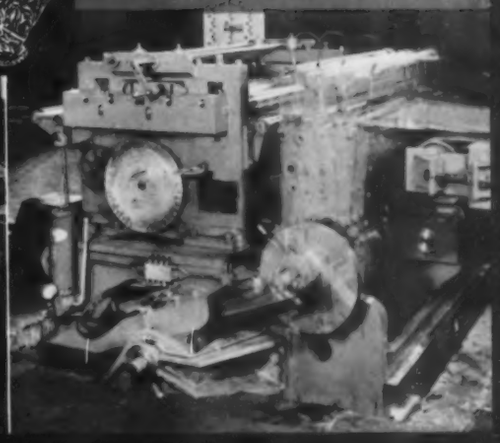


Slitting Equipment

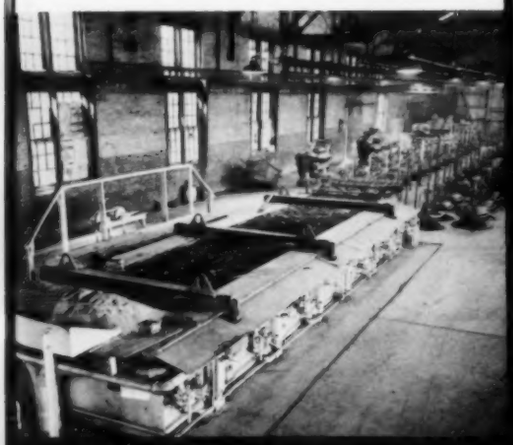
WEAN ENGINEERING COMPANY *Installations*

Wean EQUIPMENT CORPORATION

High Speed Slitting Lines

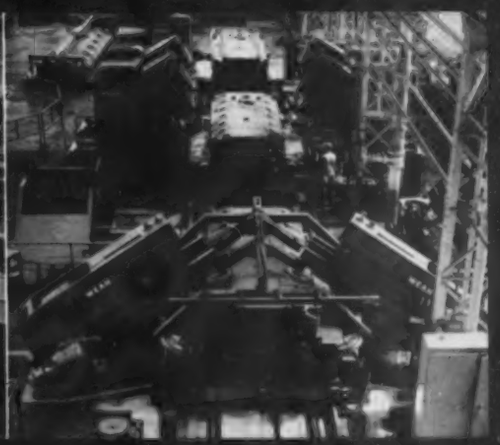


High Speed Straight, Hump and Trapezoidal Shearing Lines



Wire Making, Coating and Fabricating Machinery

Special Fabricating Machines*



Special Automation Equipment*

*The Wean Equipment Corporation has had wide experience in designing and building equipment that "automates" the tough jobs. Pictured here are two typical examples: The first is a 350-ton grinding machine that handles a huge tank hull with ease while grinding multiple surfaces with exceptional precision. The second shows a trans car line for the handling, drilling, milling and boring operations on large military combat vehicles. Lines of this nature are being adapted to many manufacturing processes.

ASSOCIATE COMPANIES

WEAN EQUIPMENT CORPORATION
Cleveland, Ohio

THE McKAY MACHINE COMPANY
Youngstown, Ohio

FLINN & DREFFEIN ENGINEERING CO.
Chicago, Illinois

THE HALLDEN MACHINE COMPANY
Thomaston, Connecticut

THE DREVER COMPANY
Philadelphia, Pennsylvania

THE WEAN ENGINEERING CO. OF CANADA, LTD.
Hamilton, Ontario

REPRESENTATIVES

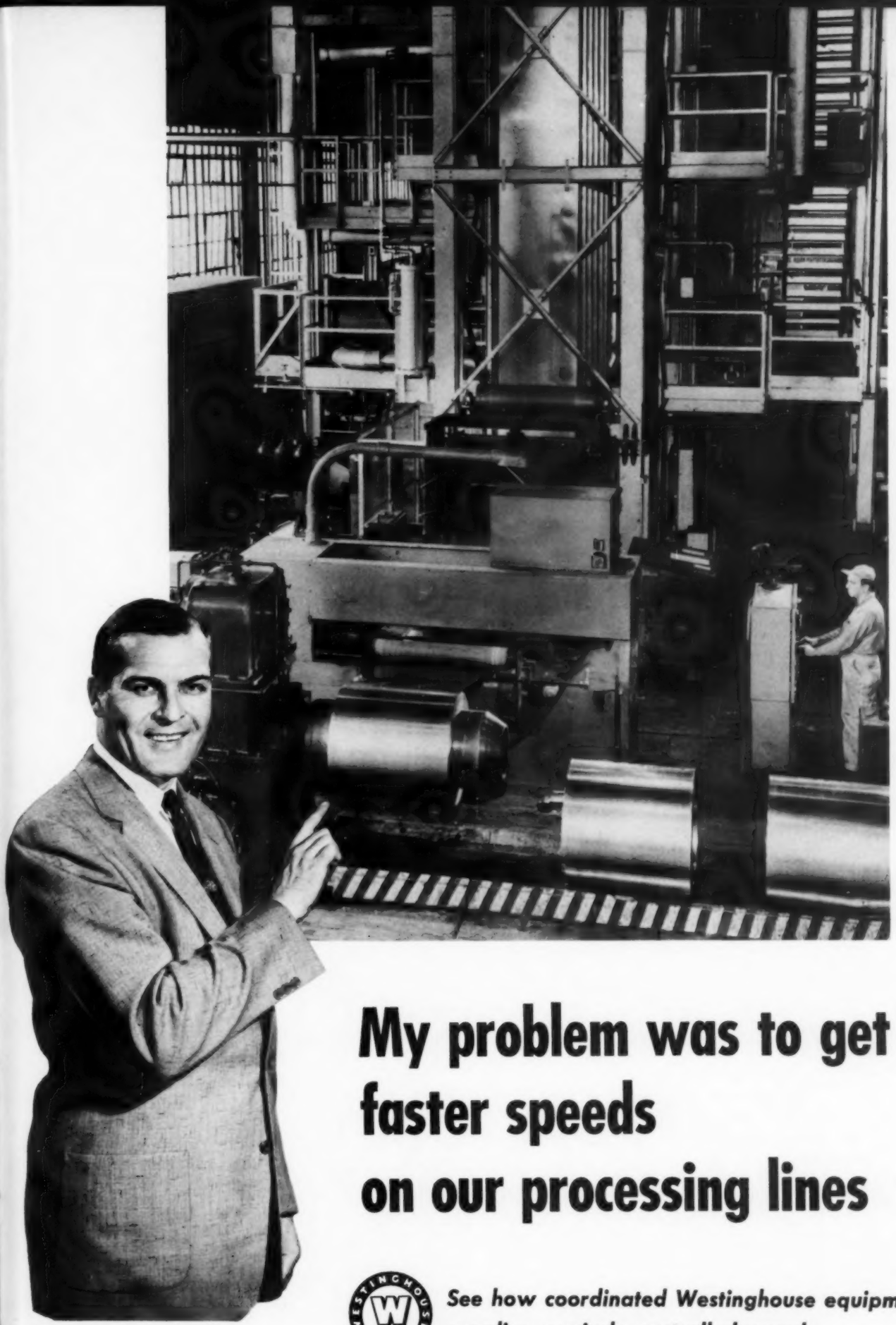
ENGLAND
JOHN MILES & PARTNER (London, Ltd.)
London, England

FRANCE
P. DAMIRON & COMPANY
Paris, France

OKURA & COMPANY
Tokyo, Japan

NORVIL COMPANY
Milan, Italy

Litho in U.S.A. 98M-554



My problem was to get faster speeds on our processing lines

See how coordinated Westinghouse equipment supplies precisely controlled speed

Constant speed and no stops... couldn't do it without automatic control

Take your annealing line, for instance. You need constant speed through the furnace in order to produce uniform quality steel. You must maintain nonstop operation for long periods.

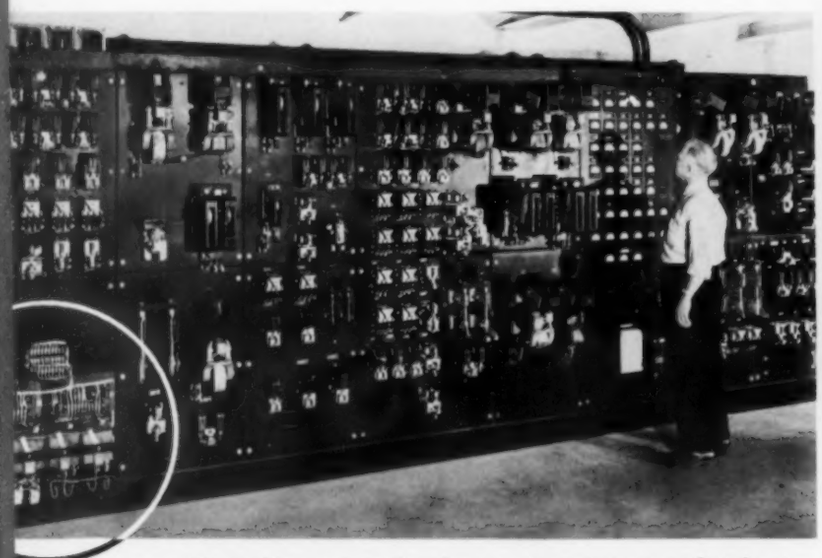
Westinghouse regulating systems, with their coordinated basic control, give your crews full automatic control of temperature, edge position, strip tension, loop position, overspeeding and resynchronization, and master-line speed. Rototrol® or Magamp® current regulators accurately control strip tension along the line, and keep speed constant through the furnace. On electrolytic cleaning lines, higher line speeds and larger coils require more accurate tension control. Proper regulator design and characteristics are the answer to the problem. Equipped with inertia compensating circuits, the regulator keeps strip tension constant at uncoiler and reel during accelerations and decelerations.

Every second counts if you're shooting for high-production pickling lines. Entry section must keep pace with the continuous process through the acid tanks. Fast acceleration and deceleration must overcome the stops that come every few minutes for welding on new coils. Westinghouse regulators speed up this start-stop process by forcing the section generator voltage to build up rapidly.

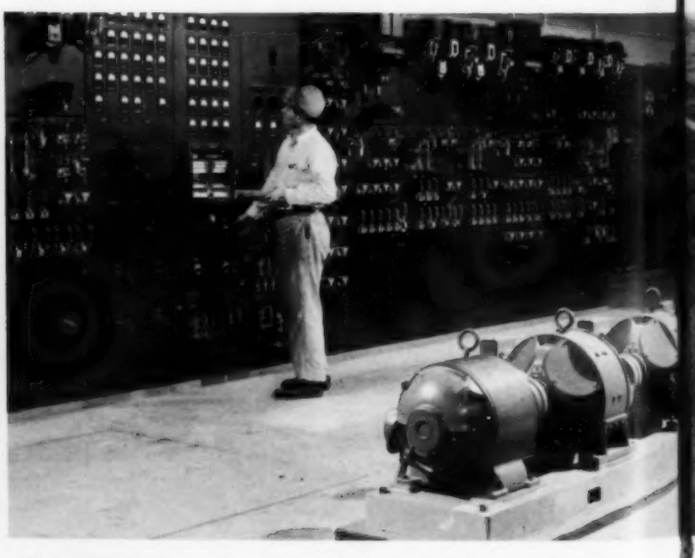
Rototrol holds constant the generator voltage when you reach production speed. A magnetic regulator at the acid tanks and a Westinghouse Photothyraton regulator at the delivery pit accurately control the depths of loops. Another timesaver: automatic speed-up of the upcoiler and the side trimmer, after the delivery end cuts out the weld, gains time in ejecting the full coil and in entering the oncoming strip in the upcoiler bending rolls.

YOU CAN BE **SURE**... IF IT'S

Westinghouse



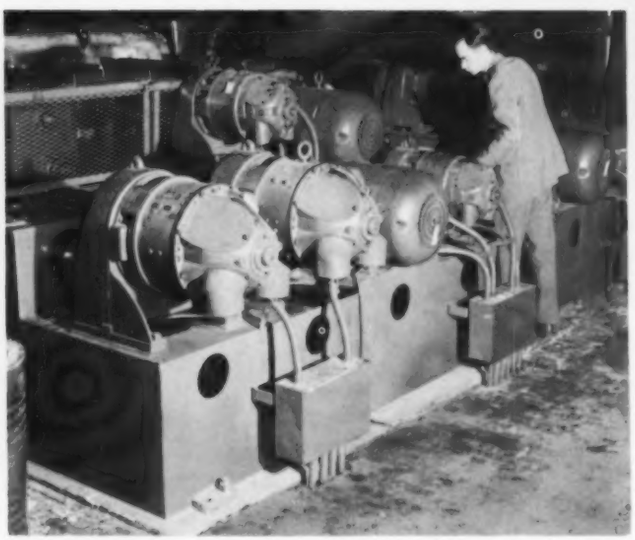
No moving parts, no brushes, no commutators, no bearings, no tubes to burn out—that's Magamp. Here (lower left) it regulates winding reel speed on 3000-fpm preparation line.



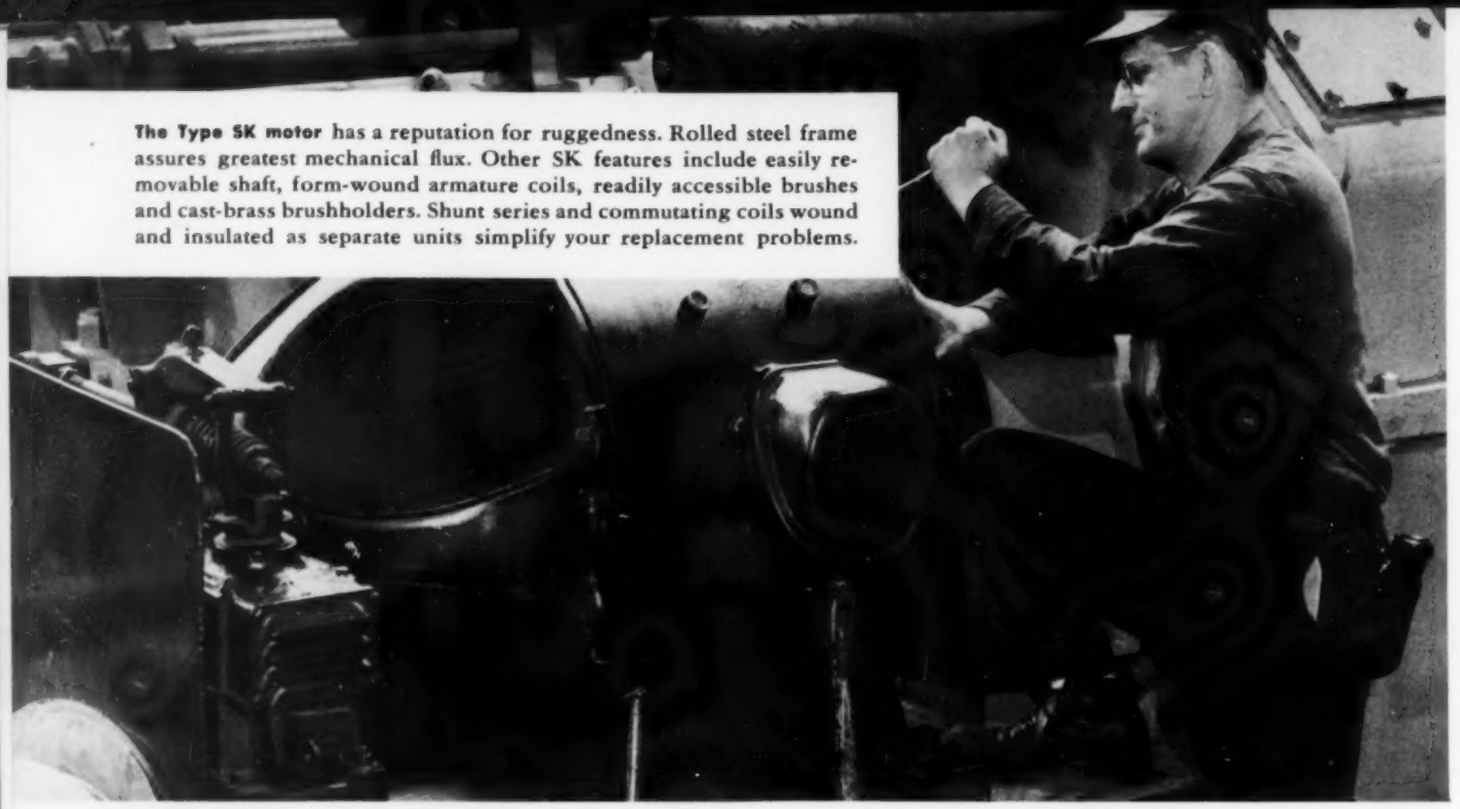
Fast acceleration and current-limit protection come from Rototrols (foreground) in this 72" pickling line control room. Westinghouse engineers plan installations like this.

Many customers like this Westinghouse type of operator's station—floor mounted and cabinet construction. Time for each phase of operation is checked by cycle counter. Switches permit selection of normal or stand-by controls.

Edge regulator consolidates all of its control and rotating equipment in a single, floor-mounted enclosure. Blower and filter, on top, pressurize cabinet to exclude dust and dirt.



Quiet but tough, these 3-hp and 5-hp Westinghouse gear-motors drive submerging rolls and scrubber back-up rolls. Simple splash system lubricates the gears and bearings.



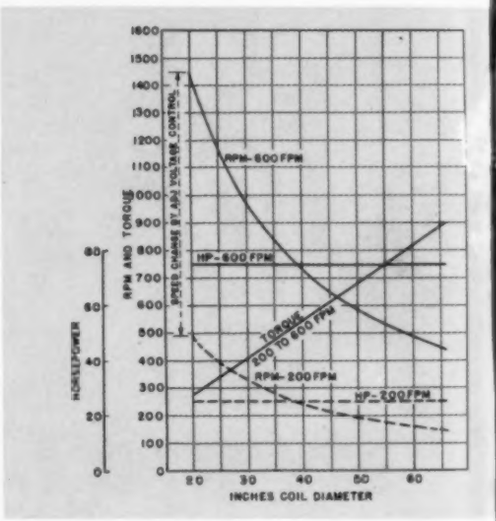
The Type SK motor has a reputation for ruggedness. Rolled steel frame assures greatest mechanical flux. Other SK features include easily removable shaft, form-wound armature coils, readily accessible brushes and cast-brass brushholders. Shunt series and commutating coils wound and insulated as separate units simplify your replacement problems.

Westinghouse motors helped us kick up our speed, widen our range

D-c motor characteristics are especially critical when your operating ranges are widened and maximum speeds climb. That's true on coil preparation lines where threading speeds are fixed by the operator's ability to handle the strip and thread the line. With rapid acceleration and deceleration needed, short-time torque build-up ratings on main generator and drive motors may be the deciding factor in machine-size selection.

Westinghouse Type MC mill motors with cast steel frames have been especially designed for heavy-duty applications. The low inertia armature allows motor to start, stop and reverse with a minimum of power. Wedges made of Class B material replace bands for holding coils in slots. This permits easier winding and less abuse of coils during winding. Completely insulated field coil assembled on a steel shell provides exceptional durability. Commutator is of bolted construction, assembled on a steel bushing and insulated with mica V rings.

Westinghouse maintenance facilities include 38 Apparatus Repair Shops, 31 Renewal Parts Warehouses, and 46 Field Service Offices. Telephone your Westinghouse representative for any of these services. Westinghouse Electric Corporation, Pittsburgh 30, Pennsylvania.



Operating requirements of 75-hp, 400/1600-rpm reel drive at full tension. Line speed—200 to 600 rpm. Coil diameter—20″ to 66″.

MP-3010 A

YOU CAN BE SURE...IF IT'S Westinghouse

Industrial Products Advertising
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3 Gateway Center
Pittsburgh 30, Pa.

Name_____

Company_____

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Please send me these books:

- ☐ Westinghouse Drives for Processing Lines.....(B-6072)
- ☐ Magamp in the Steel Industry....(B-5468)
- ☐ Questions & Answers on Processing Line Drives.....(B-6139)
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FIGURE YOUR COSTS, – *you will forget the price*

Shutting down one machine can shut down an entire department or mill. Downtime costs make the extra price of Ajax Dihedral Couplings insignificant. If you have misalignment troubles you can't afford to be without Ajax Dihedral Couplings.
AJAX DIHEDRAL
FLEXIBLE
COUPLINGS
AJAX DIHEDRAL

AJAX DIHEDRAL SPINDLE SHAFT COUPLING DESIGN is responsible for long life, trouble-free operation without the usual maintenance on spindle drives between pinion stands and rolls. Tell us your misalignment troubles.

AJAX FLEXIBLE COUPLING CO. INC.

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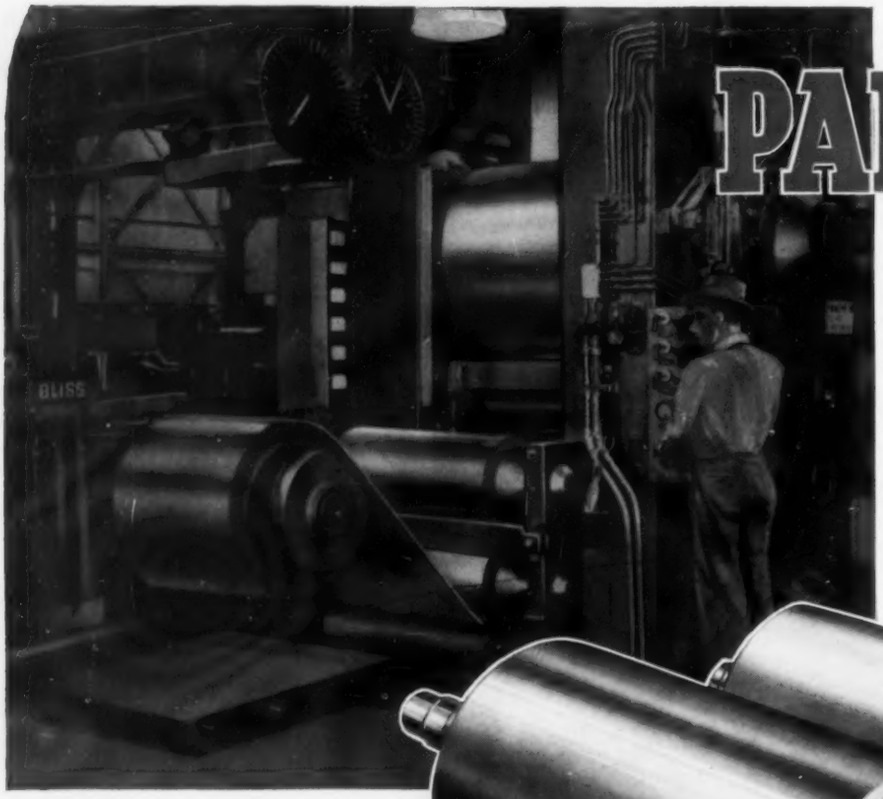
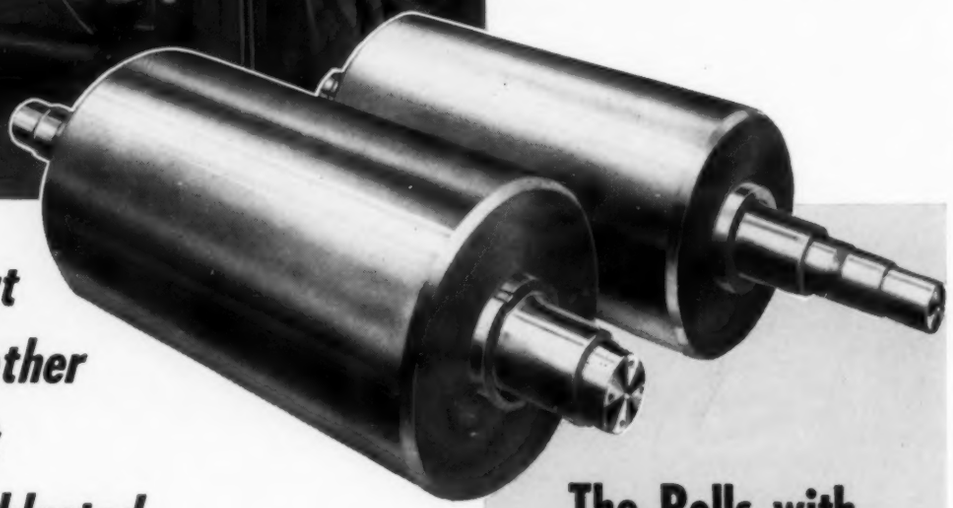
WESTFIELD, N. Y.

Increase Production and Reduce Maintenance with Y F&M

PARALLOY

Temper Mill Tension Rolls





- ***Drive them apart***
- ***Drive them together***
- ***Run them bright***
- ***Run them sand blasted***

This Bliss Temper Mill rolls more tons with Paralloy—the rolls of uniform hardness that cut temper mill maintenance cost. Users report 4-6 months service between grinds. If you are not getting good tonnage over your present rolls, or from any other material handling application—call "YOUNGSTOWN"—Strip Mill Maintenance Specialists

The Rolls with Uniform Hardness

500-600 BRINNEL
from New to Scrap Diameter

Eliminate
SCRATCHING
GALLING
PICK UP
MARKING

The Youngstown Foundry & Machine Co.
OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY
Youngstown, Ohio

16

SEE RUST-OLEUM APPLIED DIRECTLY OVER SOUND RUSTED SURFACES! MAKE THIS TEST UNDER YOUR OWN CONDITIONS AND SEE PROOF OF PERFORMANCE!

See Rust-Oleum 769 Damp-Proof Red Primer actually applied over a badly rusted surface after simple scraping and wire-brushing to remove rust scale and loose rust in the Rust-Oleum *"rusted panel demonstration."* Rust-Oleum's specially-processed fish oil vehicle *penetrates* rust to bare metal usually eliminating sandblasting and other costly surface preparations.

Rust-Oleum finish coatings in Aluminum, Green, White, Gray, Yellow, Black, Orange, Blue and others provide both *Rust Prevention* and *Decorative Beauty!* Specify Rust-Oleum for new construction, maintenance, and re-modeling. See Sweets for complete catalog and nearest Rust-Oleum Industrial Distributor, or attach coupon to your business letterhead.

RUST-OLEUM®

STOPS RUST!

There Is Only One Rust-Oleum. It Is Distinctive as Your Own Fingerprint. Resists Rain, Sun, Fumes, Snow, Heat, Salt Air, Salt Water, etc.

See local classified telephone directory under Rust Preventives or Paints for nearest Rust-Oleum Industrial Distributor.

ATTACH TO YOUR BUSINESS LETTERHEAD AND MAIL TO:
Rust-Oleum Corporation, 2441 Oakton St., Evanston, Ill.

- ☐ Please Show Me the Rust-Oleum "Rusted Panel Demonstration."
- ☐ Test Application of Rust-Oleum Over Rusted Metal Surfaces in My Plant.
- ☐ Complete Literature with Color Chart.
- ☐ Nearest Rust-Oleum Industrial Distributor.

2 High Hot Strip Mill Table Rolls in plant of Dominion Foundries and Steel Ltd., Hamilton, Ontario, Canada. Arrows indicate location of J-M Clipper Oil Seals which protect bearings against dirt and other adverse conditions

Engineers at Dominion Foundries and Steel Hot Strip Mill report:

"Bearings better protected— damaging dirt sealed out with Clipper Seals"

TABLE ROLLS of the 2 high strip mill at Dominion Foundries and Steel Ltd. must operate efficiently despite severe service conditions. Life of the Roll Bearings is constantly threatened by dirt and salt from strip mill operations.

To provide better protection, engineers replaced the original bearing seals with J-M Clipper Oil Seals. Long after this installation was made, Clipper Oil Seals are still providing far better bearing protection than the material formerly used. They seal out mill scale, salt and other foreign matter which might work into the bearing housings. They remain efficient despite high oil and air temperatures. They protect bearings by assuring clean lubrication.

Clipper Oil Seals offer many advantages wherever accurate fit, longer life and greater sealing effectiveness are required. These precision-moulded oil seals provide easy installation because the tough, dense heel affords just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

Made in both split and endless types, Clipper Oil Seals are available in a wide variety of designs, to meet practically any sealing requirement. For complete details and literature write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ont.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER OIL SEALS

HOW PERMANENT-MOLD SLIPPERS SLASH MAINTENANCE COST

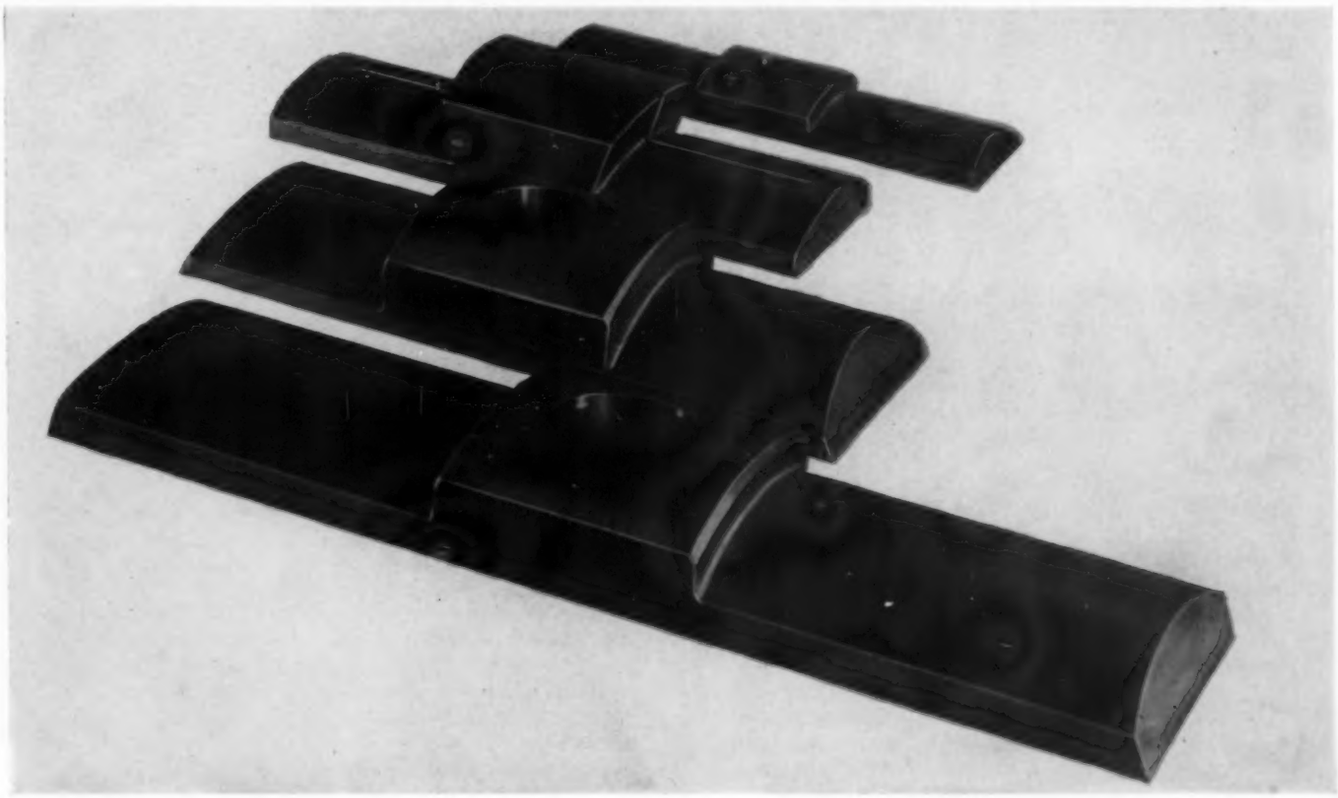
Eliminate machining, extend service life

National Bearing's carefully controlled *permanent-mold* practice makes extremely close-tolerance casting possible. This eliminates the need for costly machining and metal waste. It permits retention of a greater portion of the tough outer cast shell . . . *a guarantee of greater service life.*

These permanent-mold slippers are ready to use when you get them. The use of metal molds assures extremely smooth surfaces and greater metal density due to quick metal chilling. And permanent-mold slippers are considerably lower in price than machined slippers.

If you are interested in lowering your maintenance costs, it will pay you to investigate National Bearing. Six modern plants insure quality workmanship and prompt delivery. They, in turn, are backed by the extensive engineering and research facilities of the entire American Brake Shoe Company.

Write National Bearing Division, 4930 Manchester Ave., St. Louis 10, Mo.



AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
4930 Manchester Avenue, St. Louis 10, Mo.

HERE COMES 30,000 lbs. OF SCRAP . . . handled in a one-man load, handled over-the-road by the ROSS Carrier!

Most people don't think of industrial scrap handling as a unit-load proposition. It's usually a pretty messy operation—scrap merely dumped on any empty spot in the yard. But Central Iron & Metal Company, Battle Creek, Michigan, has put scrap handling on a fast, efficient basis simply by capitalizing on the unique advantages of the Clark-Ross Carrier.

Central Iron & Metal provides their suppliers with fabricated collection boxes or "gondolas". These vary in length from 10 to 20 feet; some have a gate at one end to allow a man to roll in a wheelbarrow and dump the load of scrap. The Clark-Ross Carrier delivers an empty gondola and picks up a "full" at each of the plants served. The Carrier speeds back to the scrap yard, drops the "full", then takes off on another call. Neither rain nor snow can stay these swift Carriers from the completion of their appointed rounds!

Central operates two 30,000 lb. Carriers. They're fast on the road (up to 40 mph) and fast on the load—takes only 3 seconds to pick up or drop a load. Central's customers like the system because of the "good housekeeping" factor. Central likes it because it's fast and inexpensive—a one-man operation which may cover several hundred miles a day.

CLARK EQUIPMENT

ROSS CARRIER LINE
Industrial Truck Division
CLARK EQUIPMENT COMPANY
Benton Harbor 135, Michigan

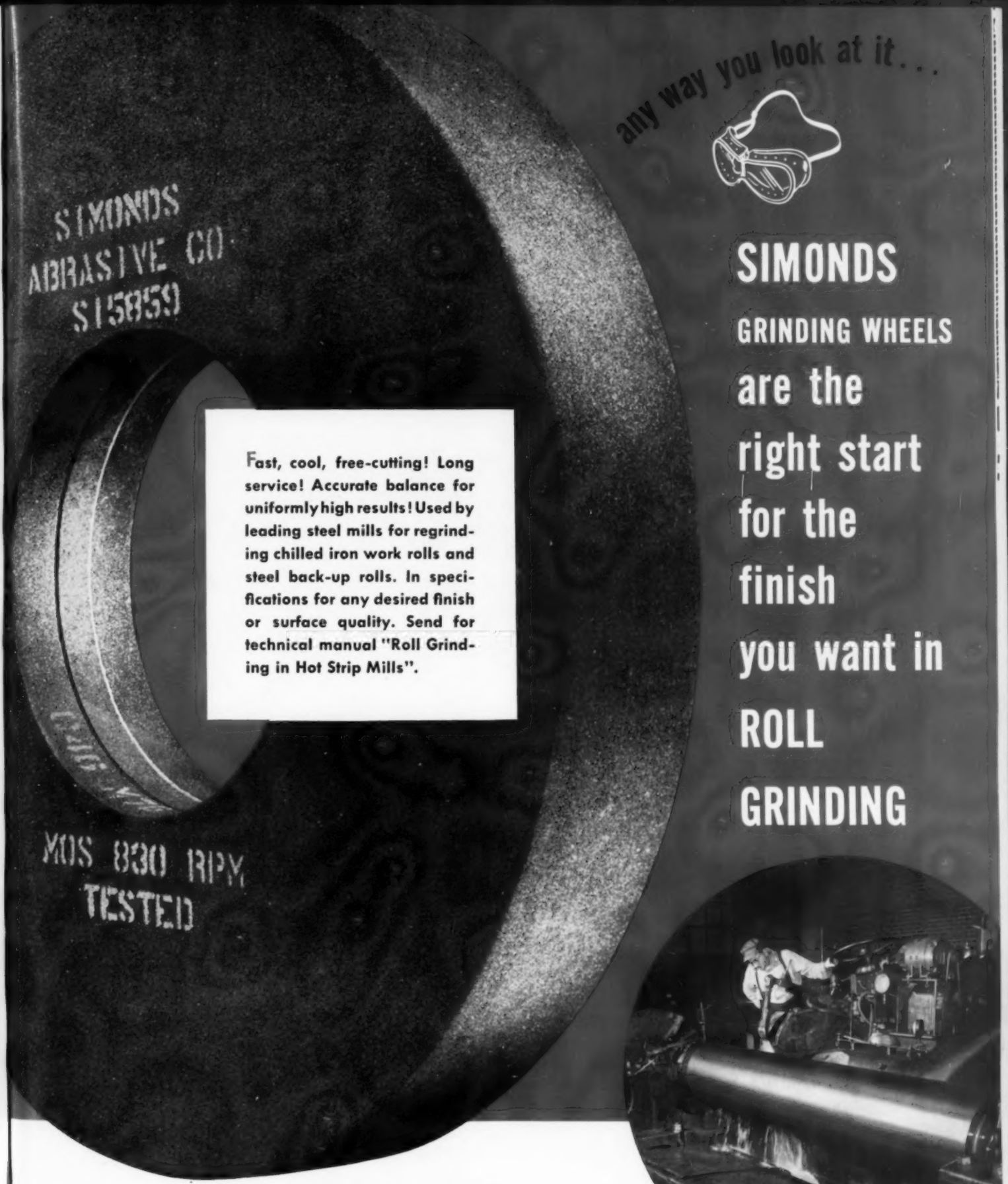
☐ Send details on the carriers

Name_____

Company_____

Address_____

City_____ Zone_____ State_____



any way you look at it . . .

SIMONDS GRINDING WHEELS are the right start for the finish you want in ROLL GRINDING

Fast, cool, free-cutting! Long service! Accurate balance for uniformly high results! Used by leading steel mills for regrinding chilled iron work rolls and steel back-up rolls. In specifications for any desired finish or surface quality. Send for technical manual "Roll Grinding in Hot Strip Mills".

SIMONDS
ABRASIVE CO.
PHILADELPHIA 37, PA.

BRANCH WAREHOUSES: BOSTON, DETROIT, CHICAGO, PORTLAND, SAN FRANCISCO • DISTRIBUTORS IN PRINCIPAL CITIES

DIVISION OF SIMONDS SAW AND STEEL CO., FITCHBURG, MASS. • OTHER SIMONDS COMPANIES: SIMONDS STEEL MILLS, LOCKPORT, N.Y., SIMONDS CANADA SAW CO., LTD., MONTREAL, QUEBEC AND SIMONDS CANADA ABRASIVE CO., LTD., ARVIDA, QUEBEC

FOR DEPENDABILITY, GRANITE CITY STEEL SPECIFIES OKOLITE-OKOPRENE CABLES

View of the new blooming mill at the Granite City Steel Co. plant in Granite City, Ill., from finished slab end. The entire mill, from the 5,000 hp motors for the two rolls to the control circuits, is wired with Okolite-Okoprene.

Simplicity of termination is one important reason for the trend to rubber-insulated high voltage cables. These are 12 kv rated Okolite insulated cables at the rear of the 6.9 kv motor switchgear.

Sverdrup and Parcel, Consulting Engineers
J. Livingston and Company, Electrical Contractors

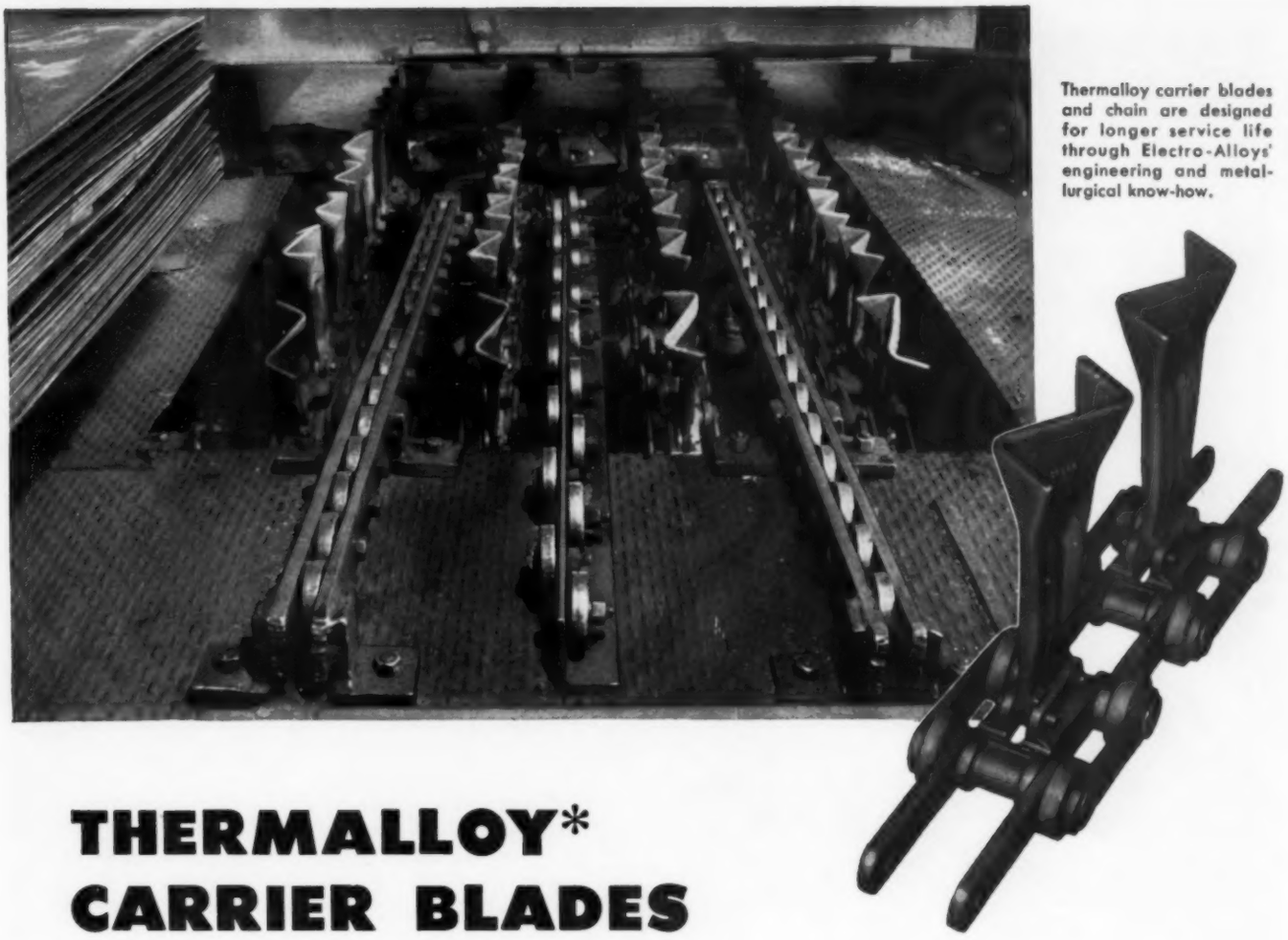
Continuous operation was a prime factor in drawing up specifications for the expansion of the Granite City Steel Company plant in Granite City, Ill. Every piece of equipment, including the electrical wires and cables, was selected on the basis of 24-hour-a-day operation.

High voltage distribution and low voltage control circuits are all wired with Okolite-Okoprene, the mold-cured, rubber-insulated cable that has established a reputation for dependability and long service life in industrial plants as well as utilities. Okolite insulation, which is applied by the Okonite strip-insulating process, is a thoroughly proved high voltage, natural rubber, oil base compound that resists heat, moisture and ozone. The Okoprene sheath, securely bonded to the insulation, provides a non-flammable weatherproof covering unharmed by long exposure to sunlight, acids, alkalies, fumes, heat and most oils.

For additional information on Okolite-Okoprene cables, write for bulletin IS-9000, The Okonite Company, Passaic, New Jersey.

OKONITE SINCE 1878 *insulated cables*

2111



Thermalloy carrier blades and chain are designed for longer service life through Electro-Alloys' engineering and metallurgical know-how.

THERMALLOY* CARRIER BLADES

. . . last 7 times longer than previous design!

Here's how Electro-Alloys' metallurgical and engineering know-how made a difference in the life of carrier blades used in a large steel plant.

In this plant, stainless and silicon steel sheets are heated in a 40-foot furnace where temperatures range from 1500°F. to 2200°F., depending on the type of steel. Carrier blades and chain entering the furnace are subjected to this high heat, and then, sudden cooling to 600°F. occurs as they return under the furnace to renew the heating cycle. Old style carrier blades lasted only three weeks.

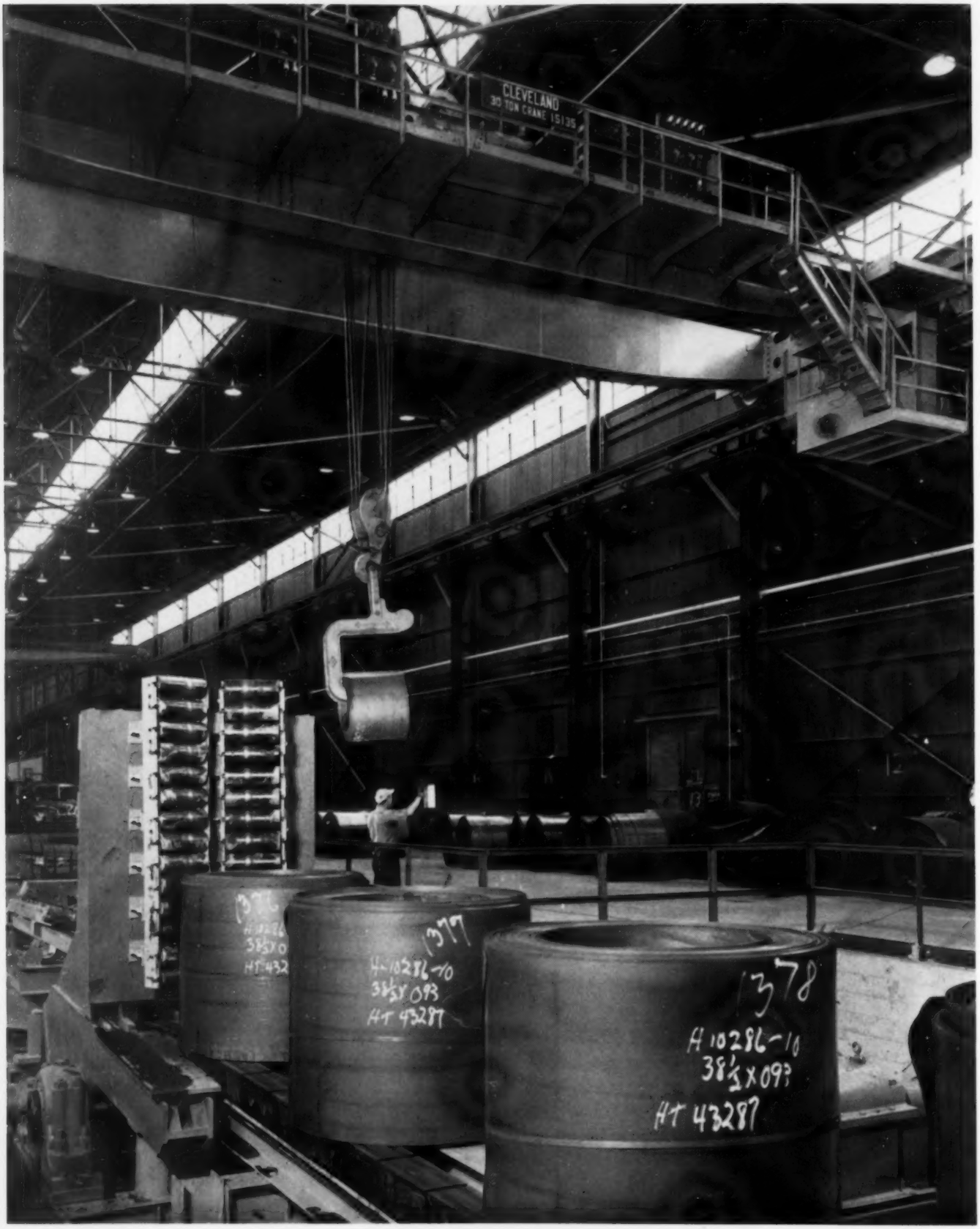
Electro-Alloys engineers observed two weaknesses in the previous design. Blade supports tended to bend . . . and carrier tips broke. By redesigning the flat, vertical supports to corrugated shapes, Electro-Alloys eliminated bending. By using a "Z" shape top, which had previously proved successful at another mill, broken carrier tips were eliminated. In its modern foundry, Electro-Alloys cast carrier blades and chain in grades of Thermalloy best suited for this operation. Results were excellent . . . *Thermalloy carrier blades now last nearly seven times as long as the old design.*

It pays to apply the experience of Electro-Alloys . . . and get longer service life from heat-resistant alloy parts by using Thermalloy. To put such knowledge to work for you, just call your nearest Electro-Alloys office, or write Electro-Alloys Division, 5006 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

*Reg. U. S. Pat. Off.



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

SPEAKING before the American Iron and Steel Institute, Dr. Ralph C. Hutchison, president of Lafayette College, said: "The issue before the world is not communism as we like to think it is. The issue yesterday was not fascism, as we liked to think it was. The issue then was the issue of human freedom. The issue now is the intent of one power to conquer the world and enslave mankind . . . Just as the United States could not remain half slave and half free, the world cannot . . . It is the battle to the death between two principles . . . Let's get across to the world that we are for the freedom of the peoples of every nation in the world. We are for their rights to peace and to protection from invasion and from exploitation, even if it be from our erstwhile friends and allies."

▲

IN the Schwab Memorial Lecture before the American Iron and Steel Institute, Dr. M. J. Kelly, president of Bell Telephone Laboratories said that the use of electronic digital systems will relieve man from the more routine and repetitive mental operations of civilian economy. He foresees the completely automatic factory, but feels it will come in a step-by-step evolution rather than a revolution of present methods. He also believes we are well on our way in the application of atomic power through nuclear fission to the peaceful pursuits of man, and estimates that the economically recoverable uranium and thorium of the world would provide an adequate energy source for thirty centuries.

▲

JUNE is well known as the month of brides, roses and graduation, but did you know it is also Dairy Month, National Ragweed Control Month and Dents-out-of-Fenders Month, and contains Park and Recreation Week, Save Your Hair Week, National Flag Week, Let's Play Tennis Week, National Swim for Health Week and National Bow Tie Week, as well as Flag Day, Fathers' Day and probably numerous other days. What ever happened to that idea for a Let-us-alone Week?

▲

THE general pattern of economic activity that currently prevails — and is likely to continue for the remainder of this year and well into 1955 — is of strong, sustaining forces, rather than a preponderance of either expansionary or contracting factors, according to Martin R. Gainsbrugh, chief economist of the National Industrial Conference Board.

T. M. GIRDLER, chairman of Republic Steel Corp., predicts the nation's business level will start a slow upward climb this fall which may make 1954 one of the five most prosperous years this country has experienced.

▲

HARRY S. TRUMAN still believes in spending your way to prosperity. He says: "Experience shows that the best way to balance the Federal budget is to have full employment and full production." He thinks the administration should spend $3,000,000,000 more and cut $4,500,000,000 from personal income taxes, which would give a $10,000,000,000 deficit. What ever happened to the old virtue of thrift?

▲

HERBERT HOOVER has proposed the addition of a new Beatitude: "Blessed are the young, for they shall inherit the national debt."

▲

IN spite of the iron and steel industry's operating rate, overall earnings are not so bad. In fact, several companies actually showed improved earnings for the first quarter. The earning record has served to strengthen the bargaining position of the United Steel Workers in the current contract talks.

▲

A friend of ours claims that a citizen is a man who wants better roads, better schools, better public office holders and lower taxes.

▲

BETHLEHEM Steel Co.'s Johnstown plant established a fine safety record by a 123-day period of accident-free operation, beginning last January 2. A total of 8,241,906 man-hours were worked without a disabling injury before a minor thumb injury brought the string to an end on May 5.

▲

IN the old days, maybe it was the switching facilities that kept children on the right track.

▲

TOTAL employment in the iron and steel industry for the first quarter of 1954 is estimated at 633,800, with a payroll of $737,969,000. In April, wage earners worked an average of 35.8 hours a week at an average rate of $2.296 per hour. Inclusion of pension, social security and insurance costs raises this figure to $2.469 per hour.

▲

WE don't know about you people but we are completely fed up with the Army-McCarthy feud on television, radio, newspapers and magazines. It seems fantastic that this wrangle should receive such attention or that it should be aired in public at all. Our friends abroad will think either that it is important or that our sense of values is bad to treat it as if it were important. Let's put it into closed sessions and give it minimum news coverage. That will act better than anything else to shorten the hearings.

▲

THE First Iron Works Restoration at Sangus, Mass., will be dedicated on September 17, marking completion of the six-year project.

When you need instrument service . . .

Ever have a tire blow out while you're traveling late at night? If it happens near a service station, you're lucky. But if it's on a lonely road far from town, you've got trouble.

When it comes to service on instruments, you don't need to take chances on being lucky. Because when you have Honeywell instruments, you've always got the comfortable feeling that service is close at hand . . . whenever and wherever you want it . . . from the world's biggest instrument service organization.

Over 110 Service Centers

No matter where you may be, there's a Honeywell service man near you. Offices are located in more than 110 cities of the United States and Canada, near every large production center.

When you run into trouble, just telephone or wire the nearest of these offices. You'll get a service specialist promptly . . . often within a few hours. This quick attention to your needs protects your production schedules, and prevents delays that can cause costly stoppages.

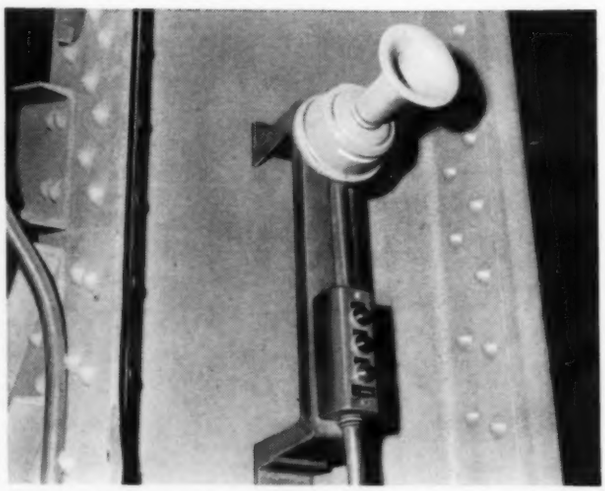
Trained Personnel

Honeywell service men are thoroughly trained for their important responsibilities. In the Honeywell factories, hand-picked men learn both the theory and practice of instrument maintenance. Then they serve an apprenticeship in the field offices, to gain further first-hand experience. You can be sure that the Honeywell man who calls at your plant is a qualified specialist, well versed in the practical art of keeping good instruments in the best condition.

Periodic Service

But why wait for emergencies—when you can prevent them with periodic service. Under a simple contract, a Honeywell man will visit your plant at regular intervals to inspect, clean and adjust your instruments and controls. The plan is economical, and can save you hours of production time. Our nearby branch office will be glad to give full details on Honeywell Periodic Service.

Molten steel temperatures at Fairless Works measured this



Signal lights and horn conveniently located near the furnace guide the operator during measurement . . . eliminate need for several trips across department to read recorder.

ElectroniK instrument on open hearth control panel at Fairless Works records bath temperatures, when the operator inserts an immersion thermocouple into the molten steel.

accurate, convenient way

AT THE Fairless Works of United States Steel . . . as in many other leading steel mills . . . open hearth operators find the *ElectroniK* bath temperature system an ideal way to chart the progress of furnace heats.

Utilizing the accuracy of platinum immersion thermocouples, this system embodies automatic signalling features that make the job of measurement simpler than ever before. The operator is guided by signal lights and a horn located near the furnace . . . doesn't need to depend on shouts or arm signals from an assistant at the control panel. These lights let the operator know when:

1 the thermocouple is correctly connected and the recorder is standardized (green light).
2 the thermocouple is preheating at the wicket hole (flashing orange light).
3 the thermocouple is at safe immersion temperature (steady orange light).
4 true metal temperature is recorded (red light and horn).

This last signalling feature permits substantial savings in thermocouple cost. The operator leaves the couple in the molten steel only long enough to get an accurate measurement. Shortening the time in the bath means that thermocouples last longer.

Your nearby Honeywell sales engineer will be glad to discuss the application of this instrument to your own open hearths or electric furnaces. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Instrumentation Data Sheet No. 6.4-8a.**

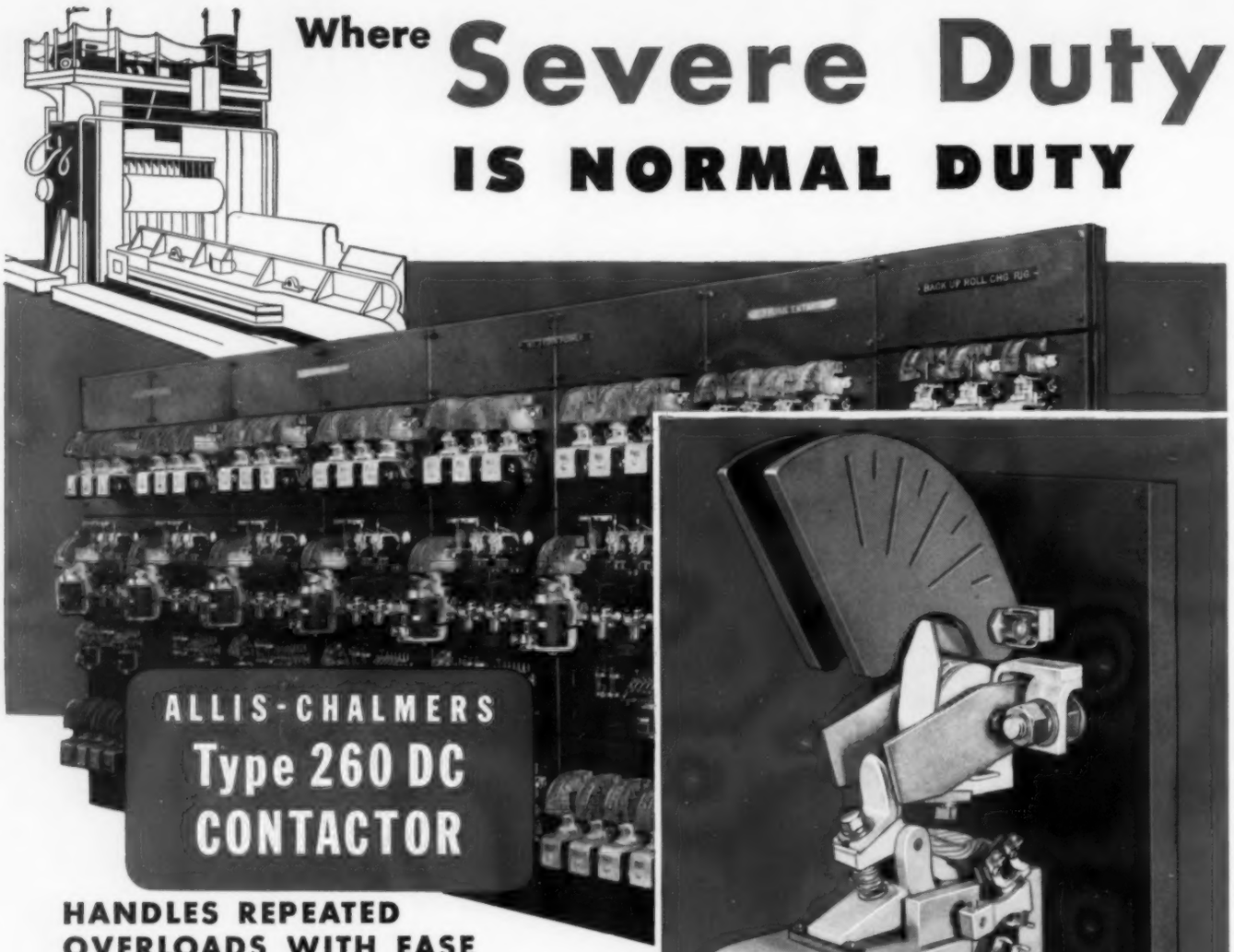
H HONEYWELL

MINNEAPOLIS **Honeywell**

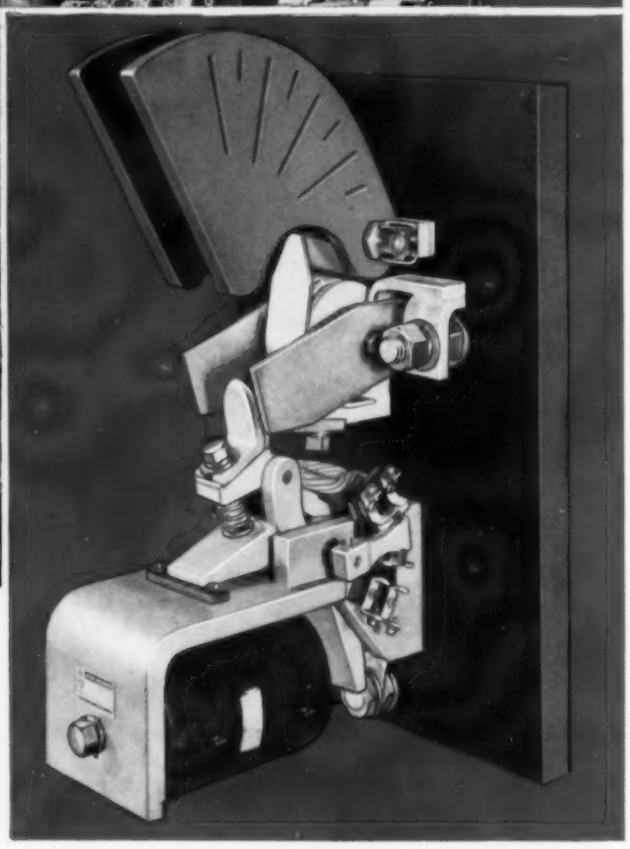
BROWN INSTRUMENTS

First in Controls

Where Severe Duty IS NORMAL DUTY



ALLIS-CHALMERS
Type 260 DC
CONTACTOR



HANDLES REPEATED OVERLOADS WITH EASE

Extra overload capacity . . . extra durability and reliability have been built into this heavy duty contactor — to make your roughest dc drive a smooth running, precision operation . . . to assure maximum production and quality with a minimum of outage time and maintenance. Principal component on the Allis-Chalmers constant potential panel, the Type 260 dc contactor is a rugged unit engineered to withstand punishing current surges inherent in steel mill auxiliary drive operation.

Here's Why!

● **Quick quenching minimizes contact burning** — Arc centering blowout uses thermal convection and magnetic action to stretch, cool and extinguish arc. Rapid circuit interruption minimizes burning and pitting of contacts.

● **All current-carrying parts silver to silver** — Main contacts are high density forged copper, plated with silver for dependability and extended life. Auxiliary contacts are solid silver . . . need no dressing.

● **Magnet coil designed for continuous duty at 110% of rating** — Coil layer wound with insulation between layers . . . vacuum impregnated to resist moisture and abuse. Operates contactor at less than 80% of rated voltage when hot. Holds at 20% of normal voltage.

● **Other features.** Rolling contact action. Arc handled on tips, current on clean heels . . . no destructive scuffing. Design simplicity eliminates troublesome linkages, arms and pivots. Lifetime *Oilite* shaft bearings need no lubrication. A-4326

SIMPLIFIED ROUTINE INSPECTION

Keeping the Type 260 contactor in top operating condition is merely a matter of preventive maintenance through routine inspection. All components are readily accessible. Arc chute lifts off to expose contacts which may be removed by loosening one bolt. Auxiliary contacts are mounted on contactor frame in full view. Operating coil is held by a single bolt.

For complete information, call your nearby Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

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Iron and Steel ENGINEER

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In This Issue

Patent Reviews — By Melvin Nord, Patent Attorney, Detroit, Mich..... 11

Temperature Stresses in Iron Work Rolls — By Charles F. Peck, Jr., Assistant Professor, Juan M. Bonetti, Former Pre-Doctoral Fellow and Frederic T. Mavis, Professor, Department of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa..... 45

Use of Plastic, Castable and Gunning Materials in Soaking Pits — By W. D. Rees, Superintendent Bar and Blooming Mill, Lowellville Works, Sharon Steel Corp., Lowellville, Ohio..... 59

System Engineering for Continuous Strip Processing Lines — By J. S. Apperson, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y..... 68

Fairless Works — United States Steel's Newest — By T. J. Ess..Following Page 76

More Than Technology — By Malcolm W. Reed, Executive Vice President — Engineering and Raw Materials, United States Steel Corp., Pittsburgh, Pa..... 77

Use of Oxygen in Steel Mills — By Glenn O. Carter, Partner, Percival R. Moses and Associates, New York, N. Y..... 80

Determination of the Optimum Current in an Arc Furnace — By W. E. Schwabe, Research Engineer, National Carbon Research Laboratories, Cleveland, Ohio..... 87

New Open Hearth Furnaces at Stelco — By E. T. W. Bailey, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada..... 91

Republic's New Open Hearth Furnaces at Cleveland — By E. C. McDonald, Superintendent, Combustion Dept., Republic Steel Corp., Cleveland, Ohio..... 99

Intra-Plant Handling of Round Billets and Pipe with Special Automotive Equipment — By J. D. Tyson, Superintendent, Warehousing and Shipping Dept., National Tube Div., United States Steel Corp., Lorain, Ohio..... 107

Alcoa Starts Operation on Giant Extrusion Press..... 119

Mills at Fairless Use New Methods — By G. E. Farrington, Chief Engineer, E. W. Bliss Co., Salem, Ohio..... 125

Packaged Rolling Mill Aids Research..... 129

Date-Line Diary..... 141

Industry News..... 151

Personnel News..... 169

Equipment News..... 179

Book Reviews..... 182

Index to Advertisers..... 187

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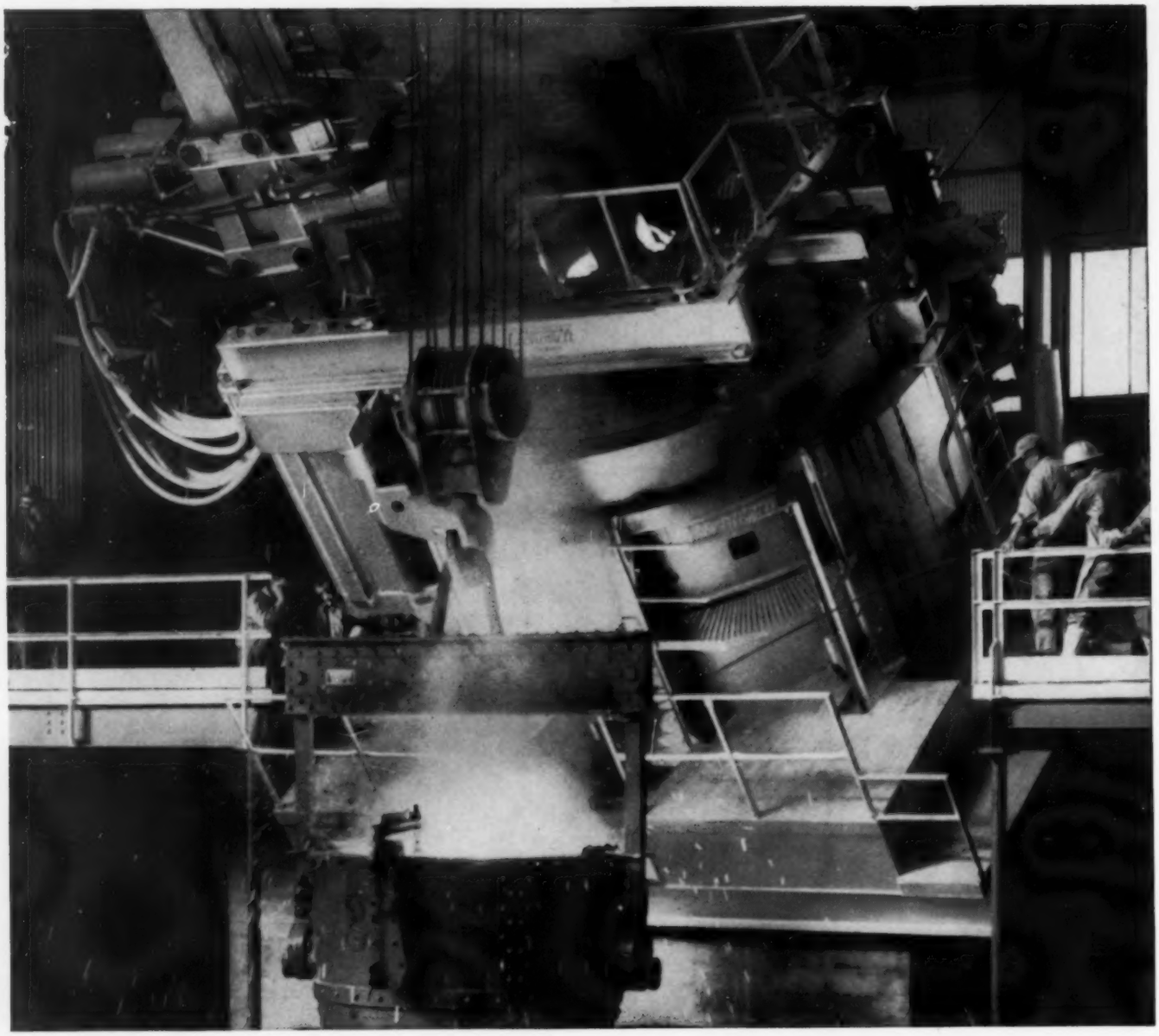

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MOORE RAPID

WHEN YOU MELT... *Lectromelt*

TEMPERATURE STRESSES IN IRON WORK ROLLS

By CHARLES F. PECK, JR.
Assistant Professor,

JUAN M. BONETTI
Former Pre-Doctoral Fellow

and

FREDERIC T. MAVIS
Professor
Department of Civil Engineering
Carnegie Institute of Technology
Pittsburgh, Pa.

. . . . a thorough study on the factors which cause roll failure should result in fewer such failures in the future . . . .

▲ "SIMPLE" failures of iron work rolls can probably be traced to such "simple" causes as inadequate materials, careless workmanship, inexpert operation, overloading, or localized overheating; but failures that puzzle makers and users of iron work rolls are seldom *simple* failures.

Behind a perpendicular break in the main body of the roll may have been an overload and behind an angular break, an overstress combined of transverse load and torque. Behind a break in the neck fillet at the end of a roll may have been high shear and torque. But who can be sure how much these primary symptoms of breakdown may have been complicated by nonuniformity of acceptable commercial materials, workmanship, and operating temperatures?

Behind larger spalls — and behind splits in the main body of the roll — may have been primarily high temperature gradients. Again, who can be sure that "cobbles," cold steel, impact loads, inadequacy or fatigue of materials or workers, or something else may not have obscured the simple link between *cause* and *effect?*

In July, 1952, Carnegie Institute of Technology, with equal co-sponsorship of the Association of Iron and Steel Engineers and the Roll Manufacturers Institute, undertook a fundamental study of causes of failures of iron work rolls limited to the following types:

1. Breaks in the main body of the roll, both perpendicular and angular.
2. Breaks in the neck fillet at end of roll.
3. Large spalls.
4. Splits in the main body of the roll.

After reviewing a literature survey that had been made by the sponsors, and after studying available data on mill operations, the authors undertook a systematic analysis of temperature stresses in iron work rolls during the rolling of hot strip in a typical stand. For a given roll, the temperature of the hot sheet, temperature of coolant, speed of rolling, and the heat-equivalent of work done by the rolls are the main independent variables of "cause"; and the temperature at points in certain patterns at any time or phase angle in the rolling cycle are the main dependent variables of "effect." The problem is not simple, because it combines unsteady mechanical and heat-energy transfer within the region of an iron cylinder — a problem for which the authors did not even seek a general algebraic solution in theory of functions. Yet the problem was solved in this investigation by numerical methods — by the calculus of finite differences. A general graphical solution which can be applied judiciously to estimate temperature stresses under wide ranges of roll size and operation is presented here. This paper summarizes that part of the first year's work which deals with the analysis of temperature stresses in iron work rolls. To keep the discussion as simple as possible the analysis is linked to the example in The Modern Strip Mill, (p 76, Association of Iron and Steel Engineers, Pittsburgh, Pa., 1941) which is a composite of many mills.

The concept and general plan of attacking the dynamic problem of analyzing stresses in iron work rolls was presented by Dr. F. T. Mavis, and subsequently the study was supervised under his administrative direction by Dr. Charles F. Peck, Jr. Juan M. Bonetti carried to completion the numerical calculations which had been started by Aristhitis C. Charnas, graduate student in civil engineering. Dr. Elio D'Appolonia and Dr. T. E. Stelson of the civil engineering department's major staff were helpful as consultants and constructive critics during the investigation.

Special thanks are due to I. E. Madsen of the Association of Iron and Steel Engineers and to J. J. Marsalka of the Roll Manufacturers Institute who, with the members of the joint committee of the Roll Manufacturers Institute and the Association of Iron and Steel

Engineers supported the study directly and through their liaison with roll manufacturers and steel producers.

The problem was subdivided into two parts:

1. To find the temperature at any two or more points in the roll and at any instant of time.
2. To find the radial and circumferential components of normal stress and the intensity of shearing stress on corresponding surfaces due to unequal temperatures.

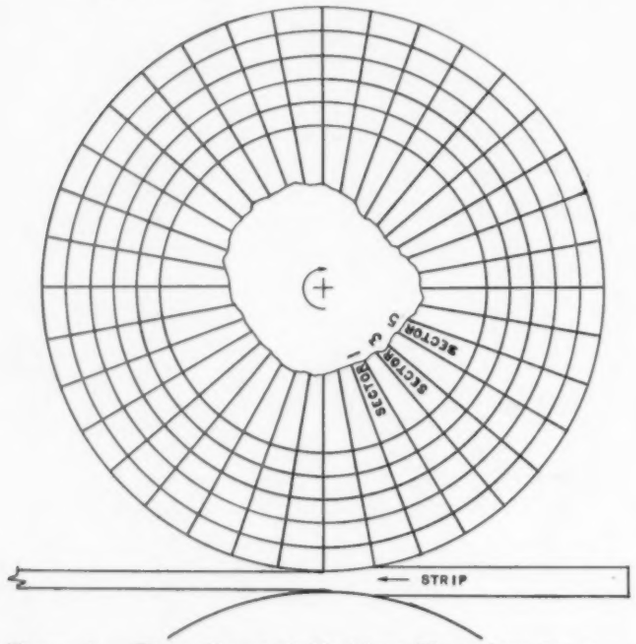


Figure 1 — The roll was divided into 36 sections for some temperature studies.

Look at Figure 1. Imagine that each roll in contact with the hot sheet is subdivided into 36 equal sectors (of 10 degrees each) and into many thin, concentric layers (of thickness ΔX each). To keep track of position relative to the starting point of contact, think of complete revolutions first (from 0 to n); sectors next (from 1 to 36); and layers last (from 1 at the surface to m . . . inward). At the outset (the 0-th revolution) sectors 1 to 5 are assumed to be in contact with the hot sheet for an instant and the relative temperatures in the surface layer of these three sectors are as shown in Figure 2 and in Table I:

Figure 2 — Chart shows variation in temperature at a point on the surface of the roll.

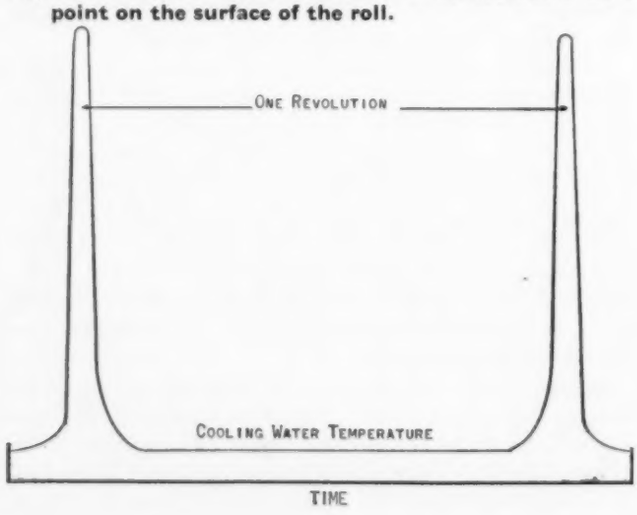


TABLE I

Revolution	Sector	Relative temperature*
0	1	11
	2	176
	3	880
	4	225
	5	20
	6	0

***These are arbitrary relative figures that can be translated into degrees F by applying model scale factors as shown later in this paper.**

As the cylinder revolves, the surface layers of new segments come in contact momentarily with the hot sheet so that heat is transferred from sheet to cylinder during $\frac{5}{36}$ of each revolution, and from cylinder to coolant during $\frac{31}{36}$ of each revolution. Consequently, the roll does not get as hot as one might expect for much the same reason that the feet of a tribal fire-dancer are not burned to a crisp — they are not in contact with the source of heat much of the time. Certainly the main body of a work roll becomes "hot" only after a long period of rolling; and the zone of "high temperature" in the work roll is but a thin collar near its surface.

Since the thickness of this collar is "small" in proportion to the circumference of the roll, the heat-flow problem becomes essentially one-dimensional — like that of a rectangular bar alternately heated and cooled at one end. Accordingly, the heat conduction equation for a one-dimensional bar insulated in its sides

$$\frac{K}{\rho C_P}\frac{\partial^2 T}{\partial X^2}=\frac{\partial T}{\partial t} \qquad (1)$$

where K = coefficient of thermal conductivity

ρ = density of material

C_P = heat capacity at constant pressure

may be used for the solution.

Before going into detail on the solution of equation (1), the question arises — what effect does the heating of a thin collar or shell have on the roll? Imagine that instead of being a solid cast roll that it is a roll with a sleeve just the thickness of the heat-affected collar shrunk onto the main body. Figure 3a shows such a roll. As the collar of this roll is heated, it will expand and eventually come loose (Figure 3b). However, in the solid cast roll, this free expansion cannot take place. Figure 3c shows how the collar will be held to the main body of the roll by tensile stresses set up in the roll. These stresses will act on the shell in a manner similar, but in the opposite direction, to pressures in a cylindrical tank, causing a tangential or "hoop" compression instead of tension. The radial tensions are certainly a contributing factor in spalls.

The secondary stresses which these radial and tangential stresses set up in the longitudinal direction may

explain perpendicular breaks in the body of the roll — breaks which mill men have long attributed to poor temperature distributions in the roll.

Since the length of roll and width of strip are great in comparison to the thickness of the heated shell, there is a very low temperature gradient along the roll's axis. At the point where the roll and the edge of the sheet come in contact, there will of course be a sharp gradient. However, studies made of broken rolls indicate that not many breaks occur at the edge of the strip.

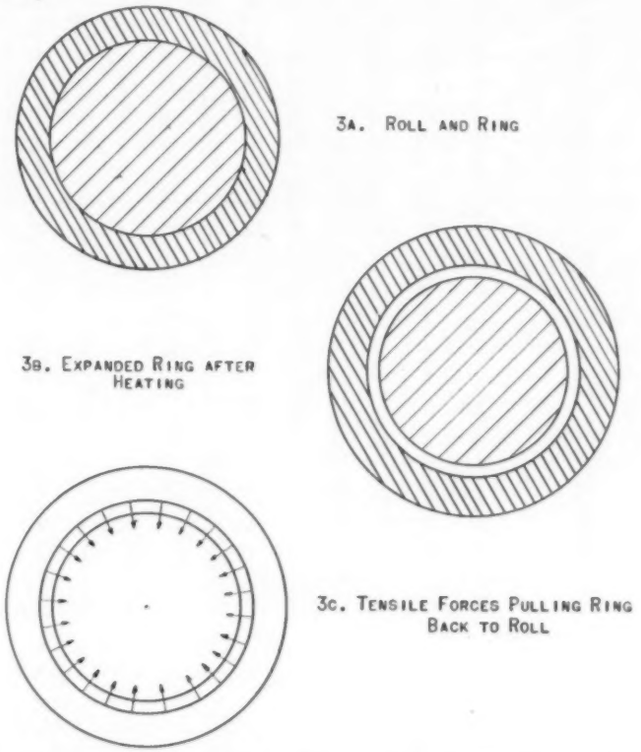


Figure 3 — Sketches show effect of surface temperature on forces in roll.

The low temperature gradient along the roll implies that thin discs of the roll may be isolated and treated as planes, and the general equation for temperature stresses in a plane may be used in the solution.

$$\frac{\partial^4\phi}{\partial X^4}+\frac{2\partial^4\phi}{\partial X^2\partial y^2}+\frac{\partial^4\phi}{\partial y^4}=\frac{\alpha E}{1-\mu}\left(\frac{\partial^2 T}{\partial X^2}+\frac{\partial^2 T}{\partial y^2}\right) \quad \ldots\ldots\ldots\ldots (2)$$

where ϕ = stress function

α = coefficient of linear expansion

E = Modulus of Elasticity

μ = Poisson's Ratio

Equations (1) and (2) form the basis for analyzing temperature gradients and resulting stresses in the rolls. They are first translated into the language of finite differences and then solved numerically — stepwise. In this form (difference equations) it is possible to keep track of what is going on in the roll at all times and not get "lost" in the mathematics.

SOLUTION OF TEMPERATURE PROBLEM

The temperatures inside the rolls were determined by analyzing the temperatures in one of the sectors shown in Figure (1) alternately heated and cooled in one end. The temperatures in this sector at any time will correspond with the temperature in the radial line in the roll that corresponds with the position of the sector.

In Figure 1 examine one of the sectors. Imagine that instead of rotating smoothly that the roll moves as though actuated by a ratchet. Sector one will then be in the position of each sector shown in Figure 1 for one-thirty-sixth of a revolution and will move instantly from position to position.

This sector is isolated and treated as a rectangular bar with heat applied on one end as shown in Figure 1. The temperature along the length of this bar at any time will correspond to the radial temperature in the roll at that point.

Figure 4 shows a representative bar at times t_1 and t_2 which differ by a small time-increment Δt. T_1, T_2, $T_3 \ldots T_m$ are the temperatures in the bar at time t_1; and T_1', T_2', $T_3' \ldots T_m'$ the temperatures at the same points at time t_2. These temperatures are at points ΔX apart — where ΔX is the thickness of the concentric laminas in Figure 2.

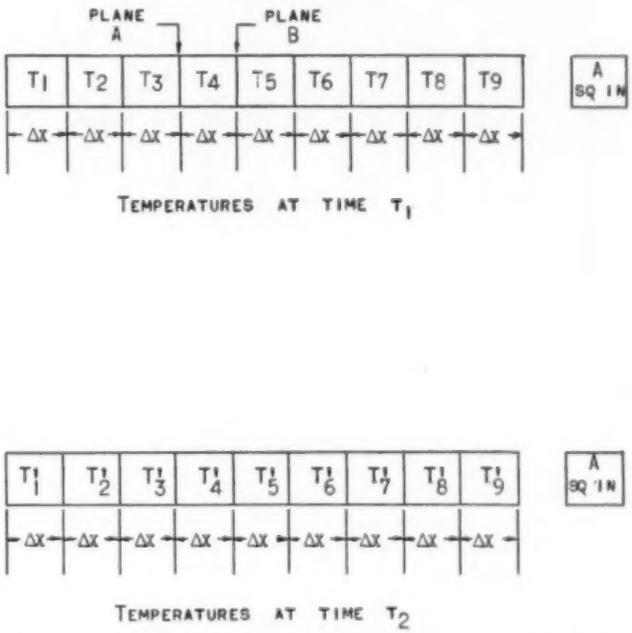

PLANE A
PLANE B
T1 T2 T3 T4 T5 T6 T7 T8 T9
A SQ IN
ΔX ΔX ΔX ΔX ΔX ΔX ΔX ΔX ΔX
TEMPERATURES AT TIME T1
T'1 T'2 T'3 T'4 T'5 T'6 T'7 T'8 T'9
A SQ IN
ΔX ΔX ΔX ΔX ΔX ΔX ΔX ΔX ΔX
TEMPERATURES AT TIME T2

Figure 4 — Sketches show temperature distribution in an analogous bar set up to simulate temperature in roll.

From "Heat Transfer," by Max Jakob, John Wiley and Sons, Inc., N. Y., 1949, vol. 1, p 374, the finite difference form of equation (1) is:

$$T_4'=\frac{T_3+T_4+T_5}{3}, \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{when } \frac{\rho C_P}{K}\frac{\Delta X^2}{\Delta_t}=3. \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

or, the thickness of the laminas and the time-increment at which the roll is held in each position are balanced so that equation (4) is satisfied. Then, the temperature of any lamina at a time t_2 is equal to the average of the temperature of that lamina and the two adjacent laminas at time t_1.

TABLE II

Temperatures in Sector (36 Sector Solution — First Revolution)

Δt	Distance into roll in increments of ΔX										
	Surface	1	2	3	4	5	6	7	8	9	10
1	11	0	0	0	0	0	0	0	0	0	0
2	176	4	0	0	0	0	0	0	0	0	0
3	880	60	1	0	0	0	0	0	0	0	0
4	225	314	20	0	0	0	0	0	0	0	0
5	20	186	111	7	0	0	0	0	0	0	0
6	0	106	101	39	2	0	0	0	0	0	0
7	0	69	82	47	14	1	0	0	0	0	0
8	0	50	66	48	21	5	0	0	0	0	0
9	0	39	55	45	25	9	2	0	0	0	0
10	0	31	46	42	26	12	4	1	0	0	0
11	0	26	40	38	27	14	6	2	0	0	0
12	0	22	35	35	26	16	7	3	1	0	0
13	0	19	31	32	26	16	9	4	1	0	0
14	0	17	27	30	25	17	10	5	2	0	0
15	0	15	25	27	24	17	11	6	2	1	0
16	0	13	22	25	23	17	11	6	3	1	0
17	0	12	20	23	22	17	11	7	3	1	0
18	0	11	18	22	21	17	12	7	4	1	0
19	0	10	17	20	20	17	12	8	4	2	0
20	0	9	16	19	19	16	12	8	5	2	1
21	0	8	15	18	18	16	12	8	5	3	1
22	0	8	14	17	17	15	12	8	5	3	1
23	0	7	13	16	16	15	12	8	5	3	1
24	0	7	12	15	16	14	12	8	5	3	1
25	0	6	11	14	15	14	11	8	5	3	1
26	0	6	10	13	14	13	11	8	5	3	1
27	0	5	9	12	13	13	11	8	5	3	1
28	0	5	9	11	13	12	11	8	5	3	1
29	0	5	9	11	12	12	10	8	5	3	1
30	0	5	8	11	12	11	10	8	5	3	1
31	0	4	8	10	11	11	10	8	5	3	1
32	0	4	7	10	11	11	10	8	5	3	1
33	0	4	7	9	11	11	10	8	5	3	1
34	0	4	7	9	10	11	10	8	5	3	1
35	0	4	7	9	10	10	10	8	5	3	1
36	0	4	7	9	10	10	9	8	5	3	1

TABLE III

Temperatures in Sector (36 Sector Solution — Second Revolution)

Δt	Distance into roll in increments of ΔX										
	Surface	1	2	3	4	5	6	7	8	9	10
37	11	4	7	9	10	10	9	7	5	3	1
38	176	7	7	9	10	10	9	7	5	3	1
39	880	63	8	9	10	10	9	7	5	3	1
40	225	317	27	9	10	10	9	7	5	3	1
41	20	190	118	15	10	10	9	7	5	3	1
42	0	109	108	48	12	10	9	7	5	3	1
43	0	72	88	56	23	10	9	7	5	3	1
44	0	53	72	56	30	14	9	7	5	3	1
45	0	42	60	53	33	18	10	7	5	3	1
46	0	34	52	49	35	20	12	7	5	3	1
47	0	29	45	45	35	22	13	8	5	3	1
48	0	25	40	42	34	23	14	9	5	3	1
49	0	22	36	39	33	24	15	9	6	3	1
50	0	19	32	36	32	24	16	10	6	3	1
51	0	17	29	33	31	24	17	11	6	3	1
52	0	15	26	31	29	24	17	11	7	3	1
53	0	14	24	29	28	23	17	12	7	4	1
54	0	13	22	27	27	23	17	12	8	4	2
55	0	12	21	25	26	22	17	12	8	5	2
56	0	11	19	24	24	22	17	12	8	5	3
57	0	10	18	22	23	21	17	12	8	5	3
58	0	9	17	21	22	20	17	12	8	5	3
59	0	9	16	20	21	20	16	12	8	5	3
60	0	8	15	19	20	19	16	12	8	5	3
61	0	8	14	18	19	18	16	12	8	5	3
62	0	7	13	17	18	18	15	12	8	5	3
63	0	7	12	16	18	17	15	12	8	5	3
64	0	6	12	15	17	17	15	12	8	5	3
65	0	6	11	15	16	16	15	12	8	5	3
66	0	6	11	14	16	16	14	12	8	5	3
67	0	6	10	14	15	15	14	11	8	5	3
68	0	5	10	13	15	15	13	11	8	5	3
69	0	5	9	13	14	14	13	11	8	5	3
70	0	5	9	12	14	14	13	11	8	5	3
71	0	5	9	12	13	14	13	11	8	5	3
72	0	5	9	11	13	13	13	11	8	5	3

Tables II and III show part of the work to solve Equation 3. The temperatures shown in Figure 1 and Tables II and III are relative to that of the cooling water (assumed to be 70 F).

As the sheet approaches the roll, the increment on the surface is heated to a temperature of 11 F above 70 F. When the roll rotates through $\frac{1}{36}$ of a revolution, the surface increment goes to 176 F above 70 F (as-

Figure 5 — Temperature distribution on a radial line is shown just before contact with sheet. Numbers on curves denote distance into roll in increments of ΔX.

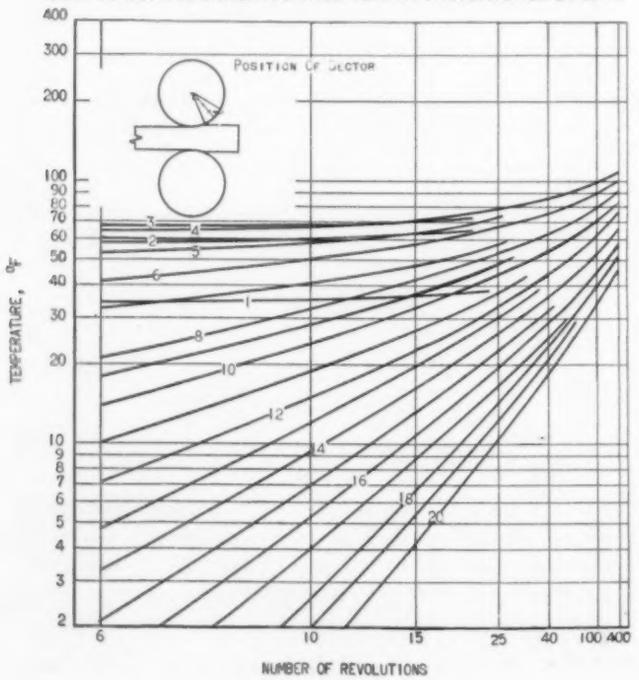
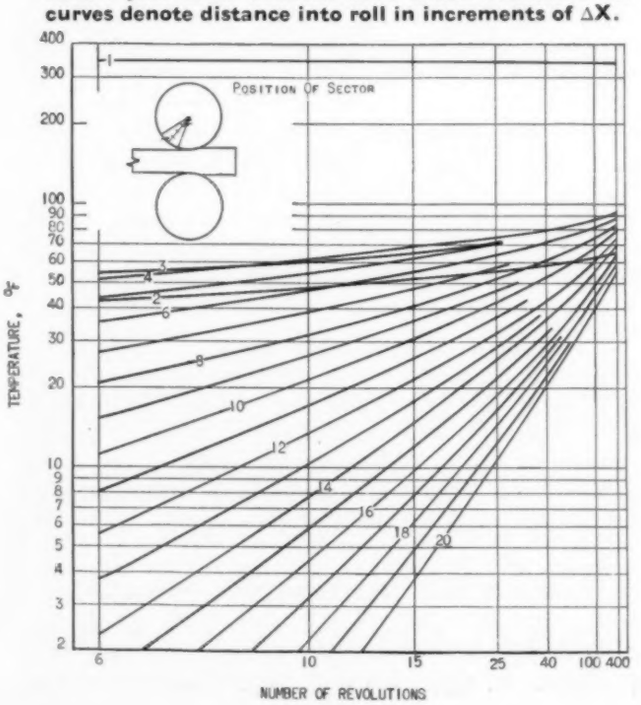


Figure 6 — Temperature distribution on a radial line is shown just after contact with sheet. Numbers on curves denote distance into roll in increments of ΔX.



signed value) while the temperature of the next increment inward has increased $\frac{11+0+0}{3}=4$ F. In like manner as the roll moves through another $\frac{1}{36}$ of a revolution, the surface has a temperature of 880 F (assigned), the next increment is $\frac{176+4+0}{3}=60$ F and the next increment $\frac{4+0+0}{3}=1$ F, all above or relative to 70 F. The tabulation of temperatures for two revolutions is shown in Tables II and III. This solution was carried out for many revolutions. A nine sector solution is shown in Figure 5. Figure 5 shows the temperatures at 20 points ΔX apart along a radial line just before the surface comes in contact with the sheet on any revolution with continuous rolling, that is, with no elapse of time between two consecutive sheets. Similarly, Figure 6 shows the temperatures just after contact with the sheet. The temperatures on seven other equally spaced radii are included in Figures 12-18. These nine figures show the model temperatures at the center of nine equally spaced sectors located as shown in the upper left hand corner of these figures. This nine-sector solution gives sufficient accuracy except at points near the roll surface where the 36-sector solution is required.

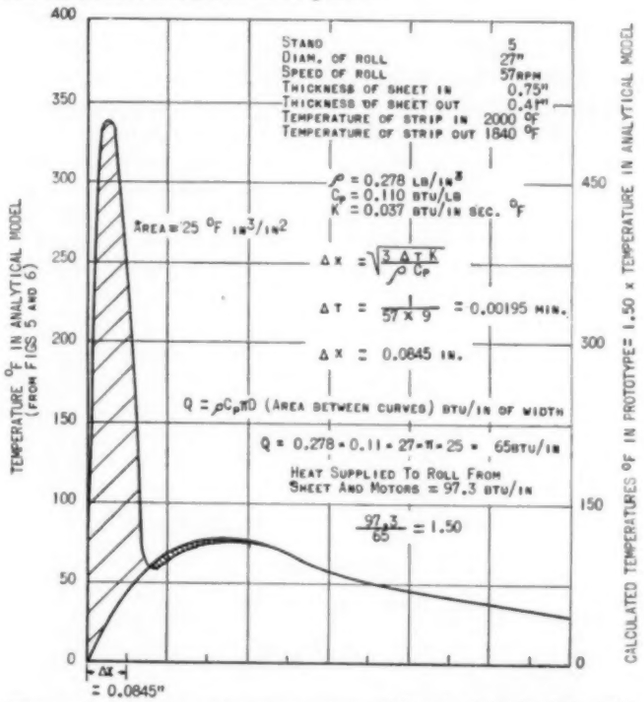

Stand 5
Diam. of roll 27"
Speed of roll 57 rpm
Thickness of sheet in 0.75"
Thickness of sheet out 0.41"
Temperature of strip in 2000 °F
Temperature of strip out 1840 °F
ρ = 0.278 lb/in³
Cp = 0.110 btu/lb
K = 0.037 btu/in sec. °F
Area = 25 °F in³/in²
Δx = √(3ΔTK/ρCp)
ΔT = 1/(57 x 9) = 0.00195 min.
Δx = 0.0845 in.
Q = ρCpπD (area between curves) btu/in of width
Q = 0.278 · 0.11 · 27 · π · 25 = 65 btu/in
Heat supplied to roll from sheet and motors = 97.3 btu/in
97.3/65 = 1.50
Δx = 0.0845"
Temperature °F in analytical model (from figs 5 and 6)
Calculated temperatures °F in prototype = 1.50 x temperature in analytical model

Figure 7 — Curves show amount of heat absorbed by the roll.

These curves are based on the surface temperatures shown in Table I. However, the curves are not limited to any particular roll — they can be adjusted to any one of the finishing stands.

To date, few measurements have been made of the surface temperatures of rolls. The temperature of the sheet between any two stands in a mill appears to be well known and the heat loss by the sheet in passing through each stand is easily computed. According to W. Trinks, "Roll Pass Design," Penton Publishing Co., Cleveland, Ohio, 1933, vol 1, p 51, nearly all of this heat is transferred into the rolls during the contact between the sheet and the roll. Therefore the temperatures in the roll may be adjusted so that the heat gained by the roll is equivalent to the heat loss from the sheet (plus the heat-equivalent of the power supplied at the roll necks).

Figure 7 shows how these adjustments are made for a particular roll. Stand 5 of the mill in Table XVIII of "The Modern Strip Mill" is used here. The example is worked at the 25th revolution which represents the passage of a ten foot slab. From Figure 5 and Figure 6 the temperature distribution along the radial lines just before and just after contact are plotted. The ordinate scale on the left is used in plotting the curves. The abscissa-scale is determined, as shown on the figure, from the physical properties dimensions and speed of rotation of the roll.

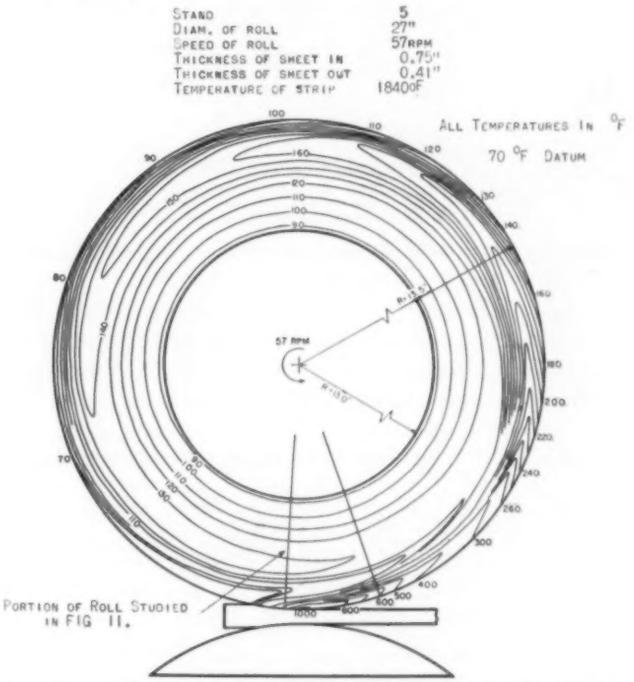

Stand 5
Diam. of roll 27"
Speed of roll 57 rpm
Thickness of sheet in 0.75"
Thickness of sheet out 0.41"
Temperature of strip 1840°F
All temperatures in °F
70 °F Datum
57 rpm
Portion of roll studied in Fig 11.

Figure 8 — Isotherms show temperature after passage of a 10-ft slab.

The area between the two curves of Figure 7 is a measure of the heat taken in by one square inch of end area of the sector in passing over the sheet. The product of this area, multiplied by the specific weight, specific heat and circumference of the roll, is the heat transferred into a one-inch width of roll during one revolution. For the analytical model of Stand 5 this is 65 Btu per in. The heat supplied by sheet and motors on the prototype mill is 97.3 Btu per in. Therefore, each temperature on the analytical model, shown in Figures 5 and 6, and in Figures 12-18, must be multiplied by $\frac{97.3}{65}=1.50$ to conform to the prototype-temperature. The ordinate-scale on the right of Figure 7 shows prototype-temperatures on the two radii of Figures 5 and 6.

Figure 8 shows the lines of equal temperature-increase which are plotted using the radial temperature distributions. Diagrams similar to Figure 8 for the other

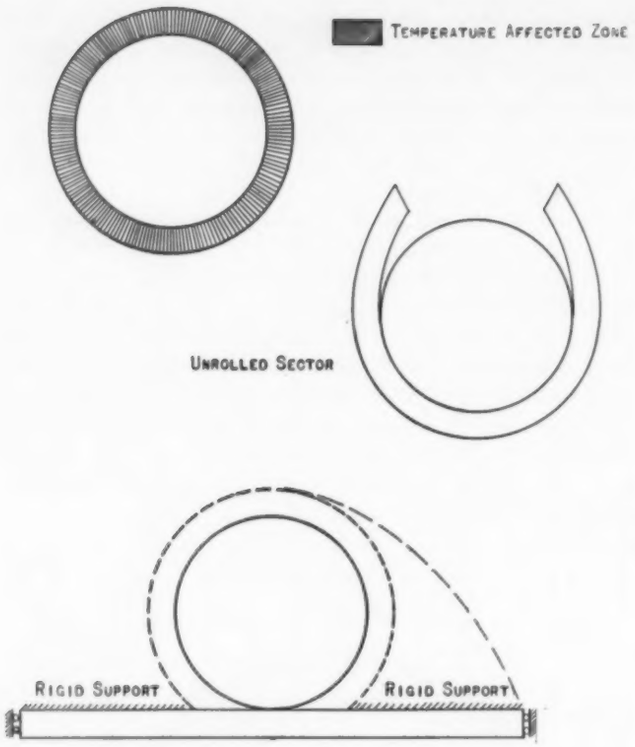


Figure 9 — Similarity between rolled shell of roll and plate is shown by these sketches.

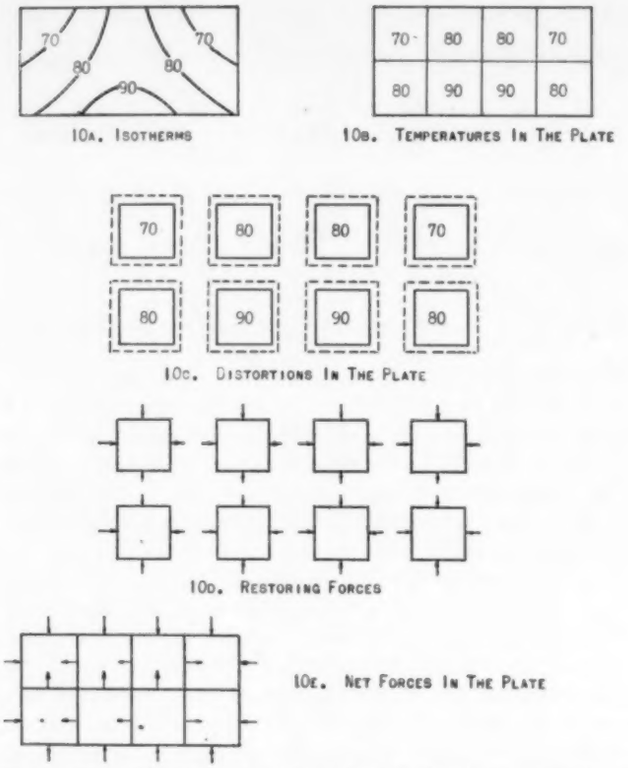


Figure 10 — Sketches show how forces, due to temperature differences, are set up in the idealized problem.

five finishing stands are shown in Figures 19 through 23. From these diagrams the temperature at any point inside of the rolls may be readily found.

SOLUTION OF THE TEMPERATURE STRESS PROBLEM

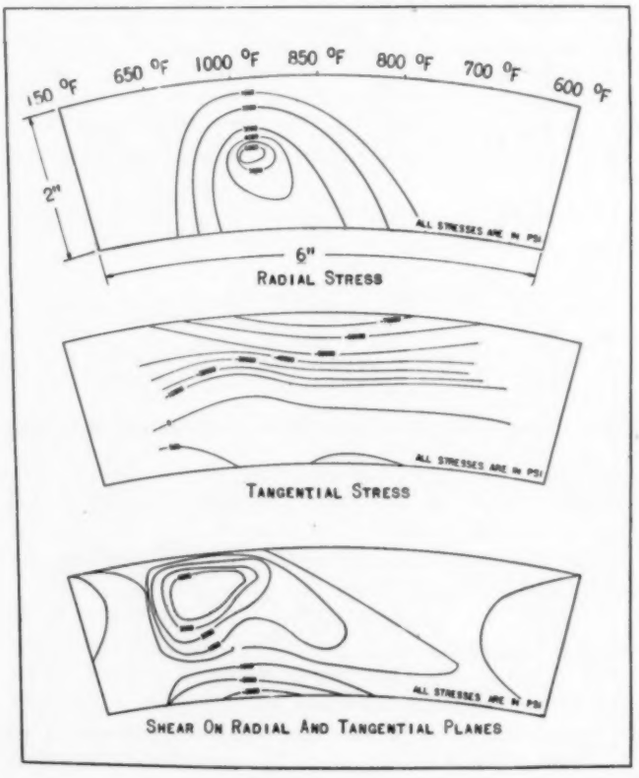
Equation 2 is the general differential equation for use in solving for the temperature stresses in solid bodies. To use this equation, the temperature gradients must be expressed as a continuous function. For the particular problem of the roll, where we have the temperatures at selected points, it is impracticable to express these temperatures in equations. However, a method was developed which will solve for the stresses directly from the temperatures in the roll.

Figure 7 shows that the heated portion of the roll is a thin shell. (For the 27-in. roll studied, the heated zone is only about one-inch). The temperature gradient along the roll is low since the sheet has nearly uniform temperature throughout its width. Therefore the stress problem may be solved by taking this thin shell as a rectangular plate instead of as a circular ring without introducing much error.

Figure 9 shows how the shell is approximated by a plate. The outside shell is "unrolled," and the action of the remainder of the roll body is simulated by fixed supports. The ends of the plate are allowed to expand toward the free surface of the plate as would occur at the junction of the two ends when the plate is "rolled" around the body.

Figure 10 illustrates how to solve for the stresses in this problem. First consider a portion of the plate as a solid body with isotherms drawn corresponding to those in Figure 8. Next, divide the plate into squares and determine from the isotherms the average temperature of each square (Figure 10b). Now cut apart the squares . . . Each square will expand because of the temperature increases. Try to fit them together but they will not fit unless forces are first applied to return the squares to their original shapes (Figure 10d). Apply these forces and fit the plate together. There will be a resulting unbalance on the faces because the restoring forces are

Figure 11 — Sketches show stresses due to temperature in the roll. See Figure 8 for the portion of the roll studied.



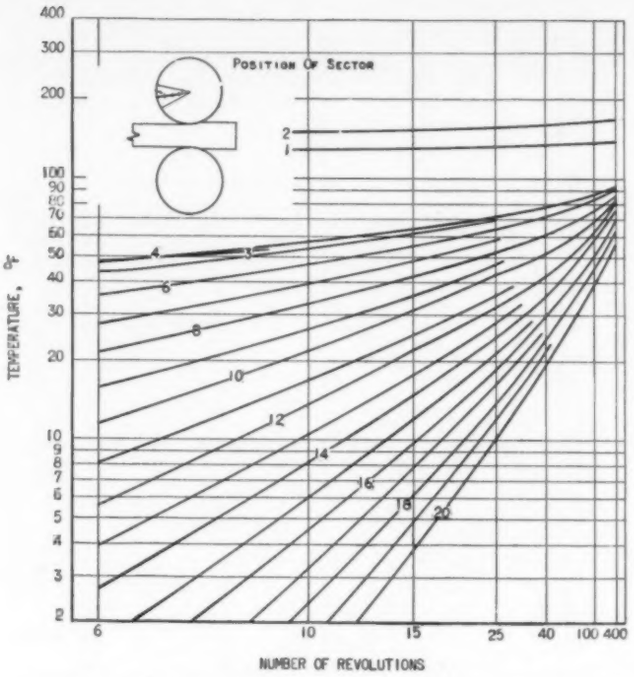


Figure 12 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.

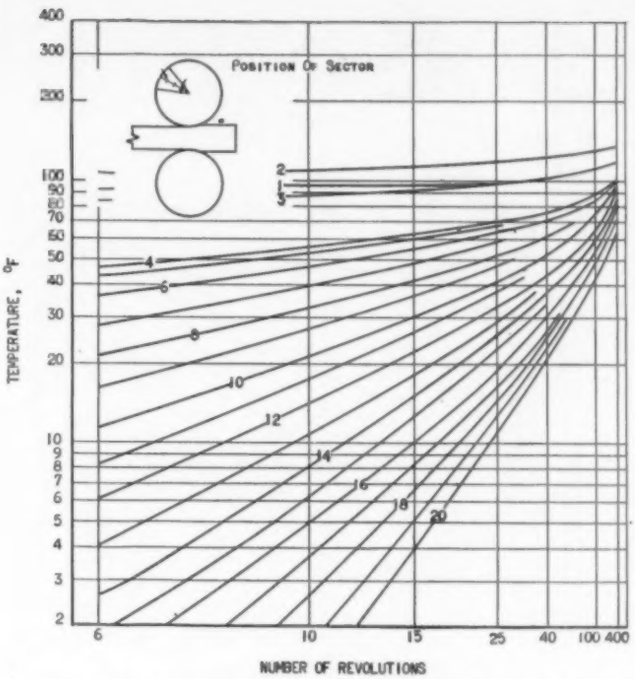


Figure 13 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.

not necessarily equal and opposite. The plate must then deform until these forces are "relaxed" to zero on every face. This will change the stresses in the plate from those which exist when the squares are fitted together by an amount equal to the stresses caused by forces equal and opposite to the unbalanced forces in Figure 10e.

The problem may now be solved stepwise:

1. Divide the plate into a grid.
2. Determine the average temperature increase for each square in the grid.
3. Determine the stresses necessary to keep the square from expanding under this temperature increase.
4. Determine the unbalanced stress on each interface when the squares are assembled.
5. Apply external forces equal and opposite to the unbalanced stresses on each interface of a similar plate and determine the resulting stresses.
6. Combine the results of steps four and six to determine the final stresses.

Step five is most readily accomplished by replacing the plate with a lattice analog. The mechanics of the lattice analog has been published and is not included

Figure 14 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.

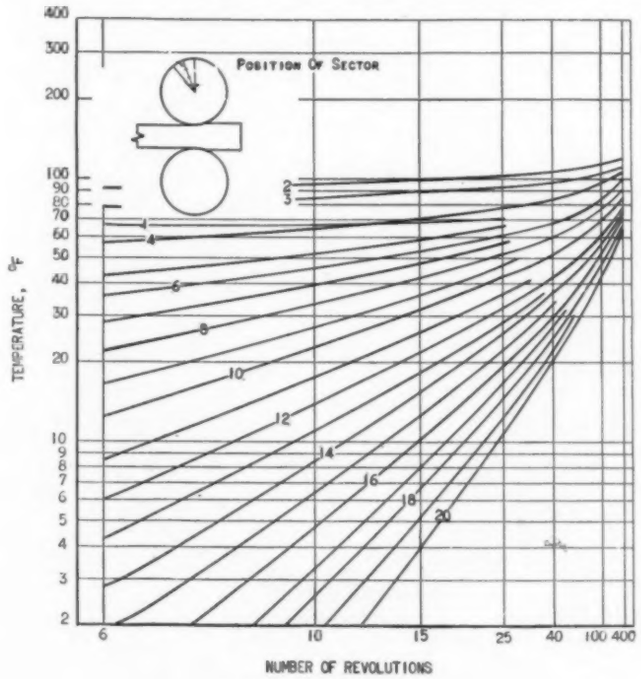
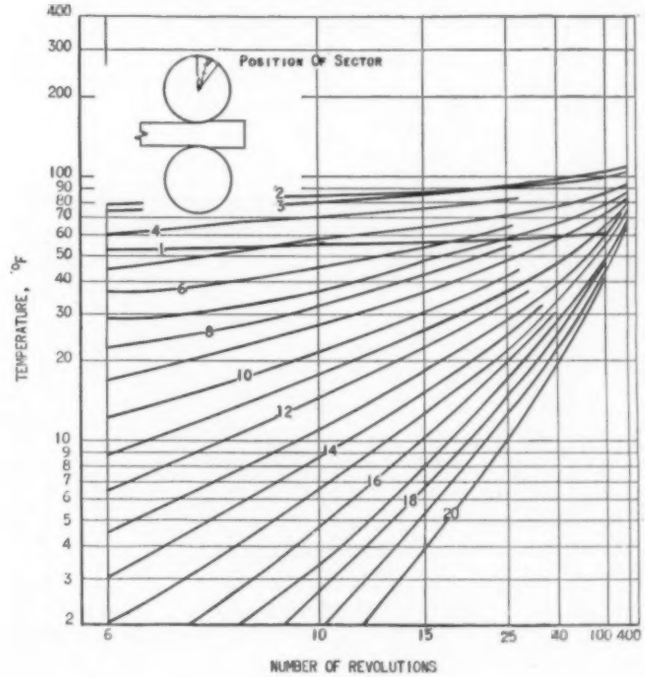


Figure 15 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.



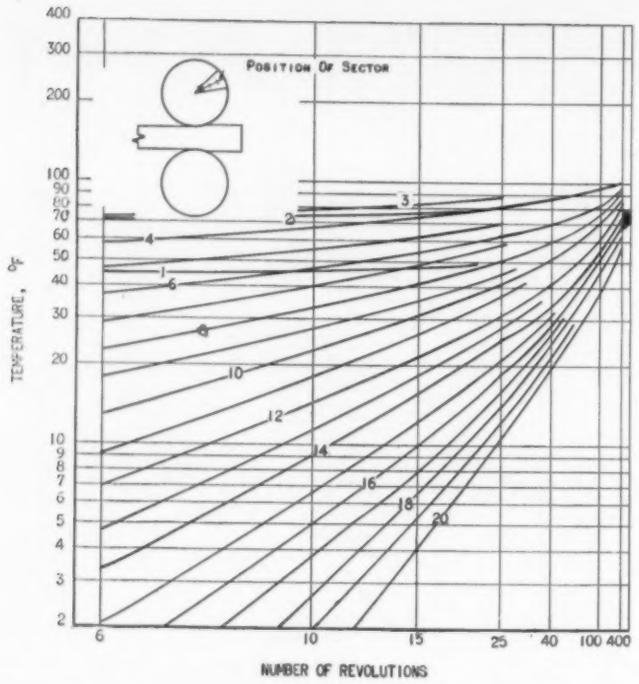


Figure 16 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.

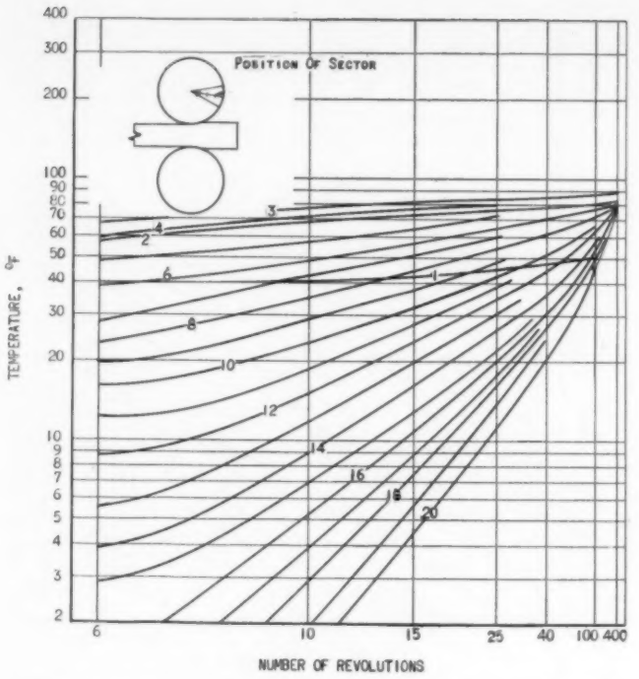


Figure 17 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.

in this report. See "A Lattice Analogy for the Solution of Stress Problems," by D. McHenry, Journal of the Institution of Civil Engineers, No. 2 Dec. P. 43, pp 59-82. However, the solutions of the lattice for a series of "unit" unbalanced forces acting separately are given in Appendix C. These solutions make it possible to obtain the stresses caused by any unbalanced force system without solving the lattice. The method for use of these solutions is also shown in the appendix.

Figure 11 shows the stress distribution in the portion of the roll in Stand 5 indicated on Figure 8. These stresses were determined using the method outlined above.

SUMMARY

This report has presented a numerical method for calculating temperature stresses in iron work rolls

Figure 18 — Temperature distribution on a radial line is shown for the roll position shown in the sketch.

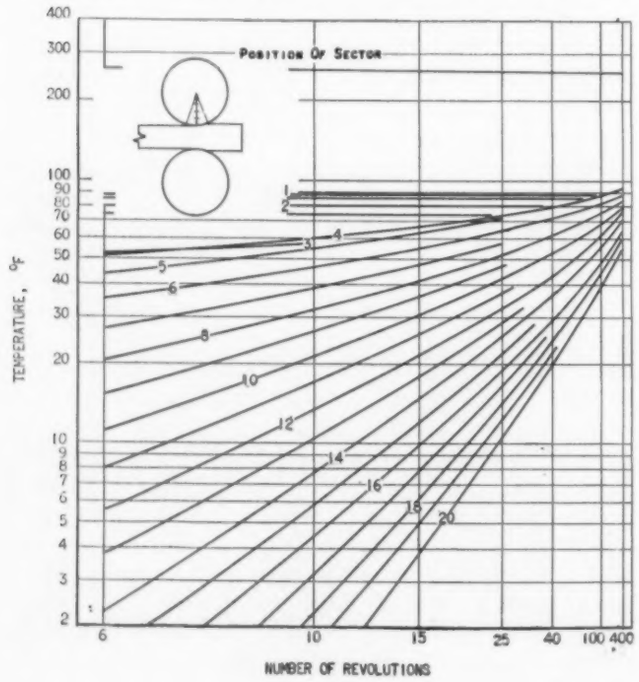
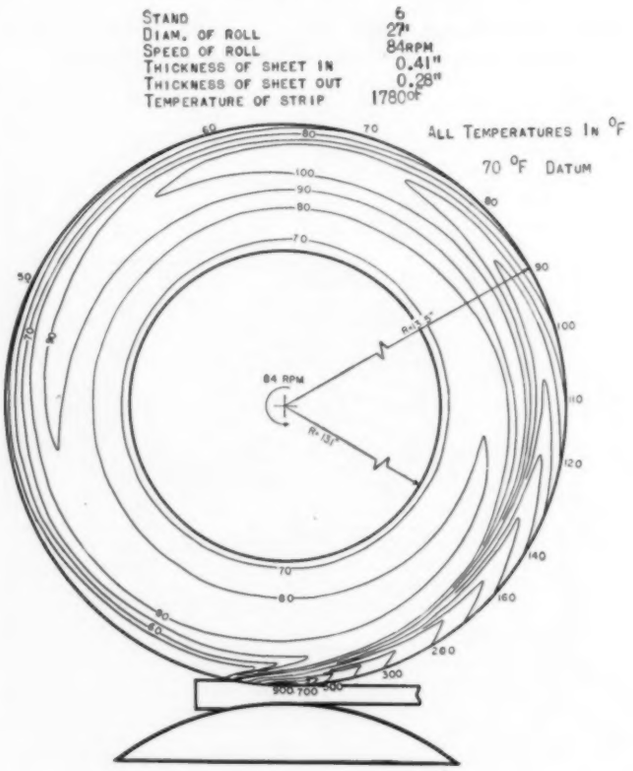


Figure 19 — Isotherms show temperature after passage of a 10-ft slab through stand No. 6.



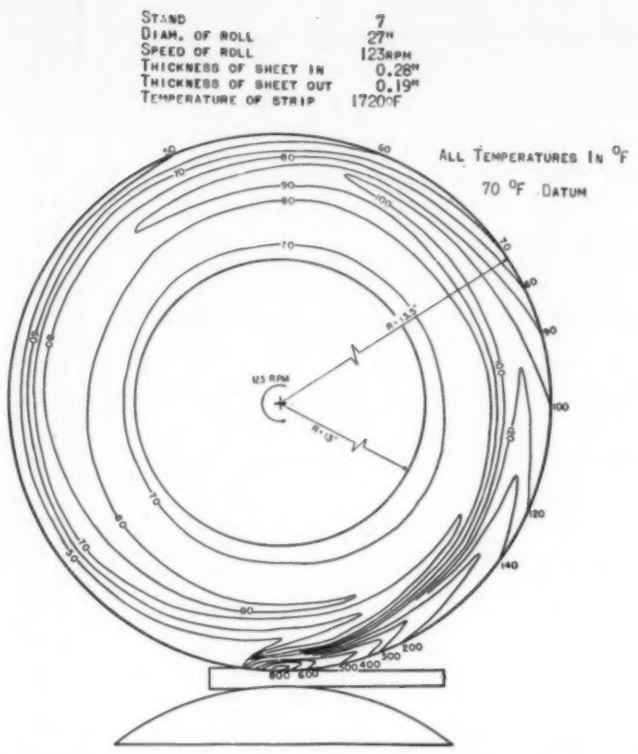


Figure 20 — Isotherms show temperature after passage of a 10-ft slab through stand No. 7.

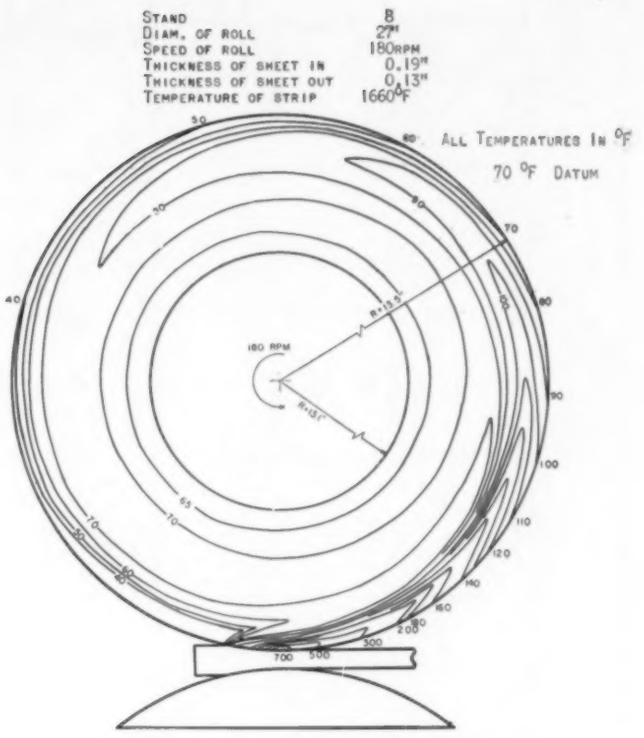


Figure 21 — Isotherms show temperature after passage of a 10-ft slab through stand No. 8.

during rolling. The results obtained for the example mill are shown in Figure 11. The temperature distribution in the roll is shown in Figure 8. The maximum temperature gradient in the roll is 12,000 F per in. The maximum resulting direct stresses are about 6000 psi tension radially, and 70,000 psi compression tangentially. The maximum shear on tangential and radial planes is about 4000 psi.

The computed temperatures for the hypothetical mill compare favorably with the few observations that the authors have made on rolls in service. The method of computation is sound, and computed temperatures are

Figure 22 — Isotherms show temperature after passage of a 10-ft slab through stand No. 9.

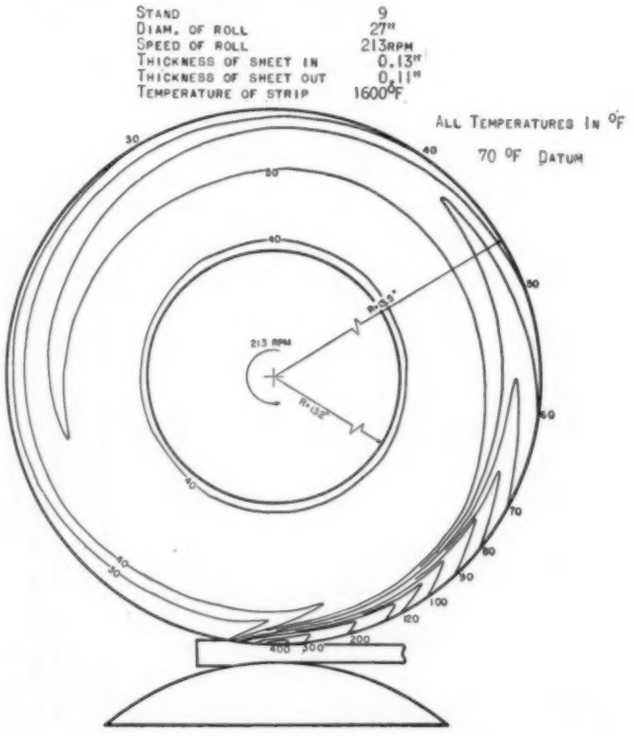
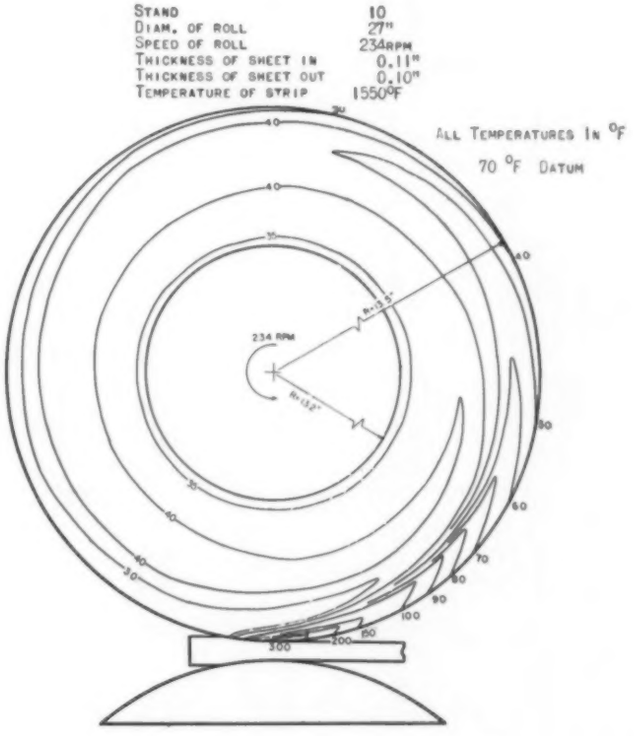


Figure 23 — Isotherms show temperature after passage of a 10-ft slab through stand No. 10.



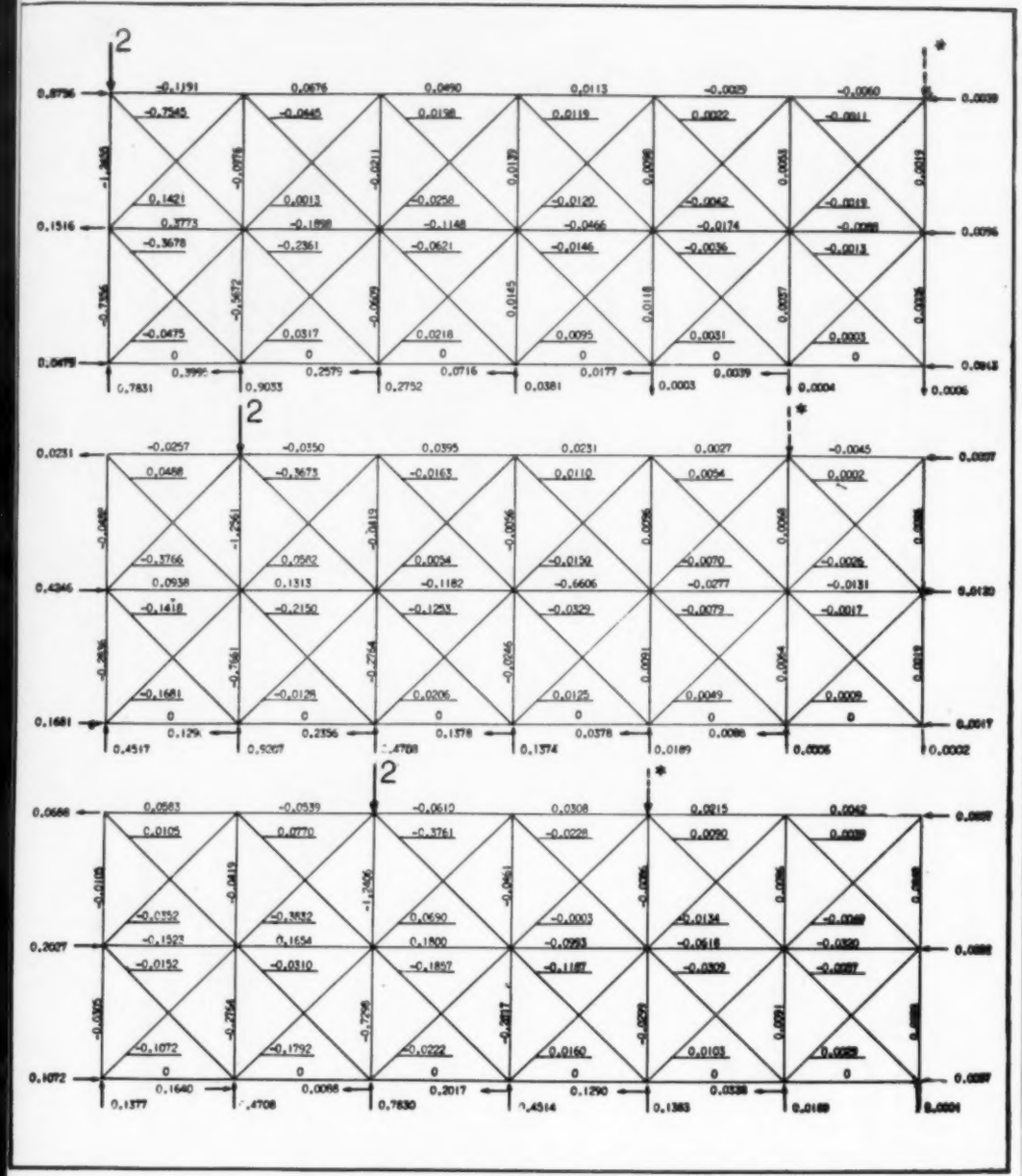


Figure 24 — Diagram gives influence ordinates in the various bars for a unit simulated load of 2 in the panel points shown. If load is applied to the panel indicated by asterisk and dotted arrow, values for stresses will be similar on the corresponding points on the other side of the center of the truss.

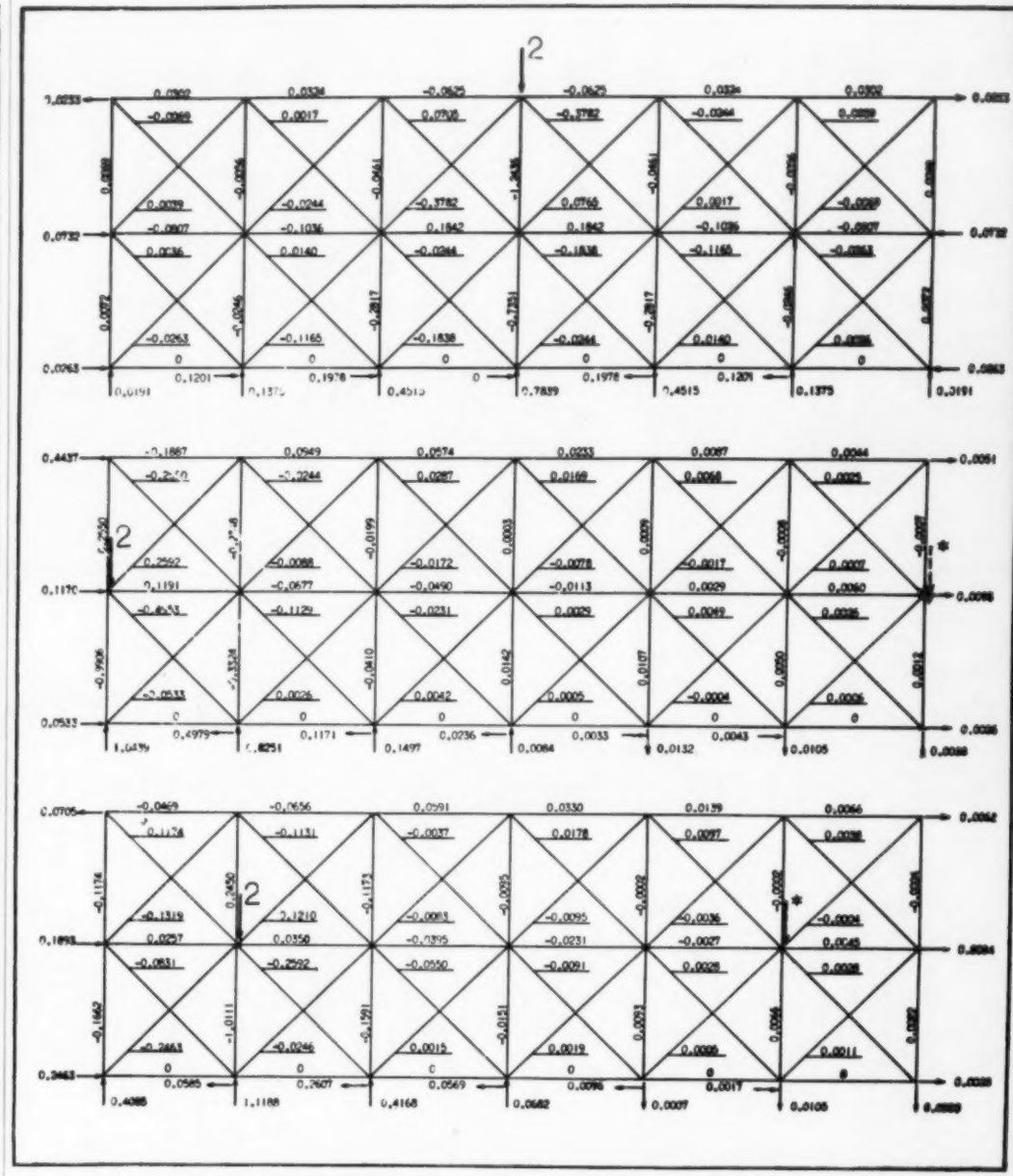


Figure 25 — Diagram gives influence ordinates in the various bars for a unit simulated load of 2 in the panel points shown. If load is applied to the panel indicated by asterisk and dotted arrow, values for stresses will be similar on the corresponding points on the other side of the center of the truss.

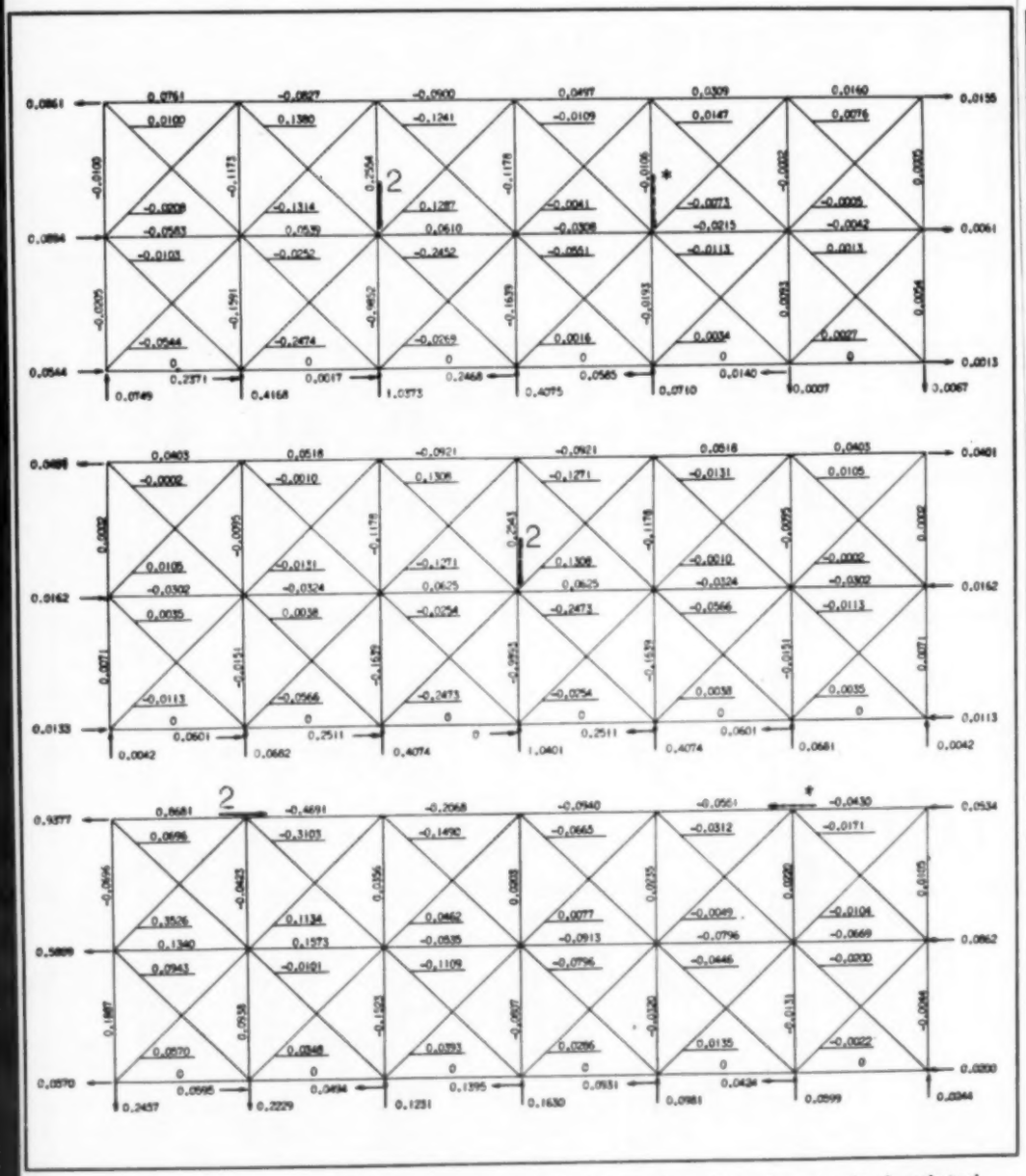


Figure 26 — Diagram gives influence ordinates in the various bars for a unit simulated load of 2 in the panel points shown. If load is applied to the panel indicated by asterisk and dotted arrow, values for stresses will be similar on the corresponding points on the other side of the center of the truss.

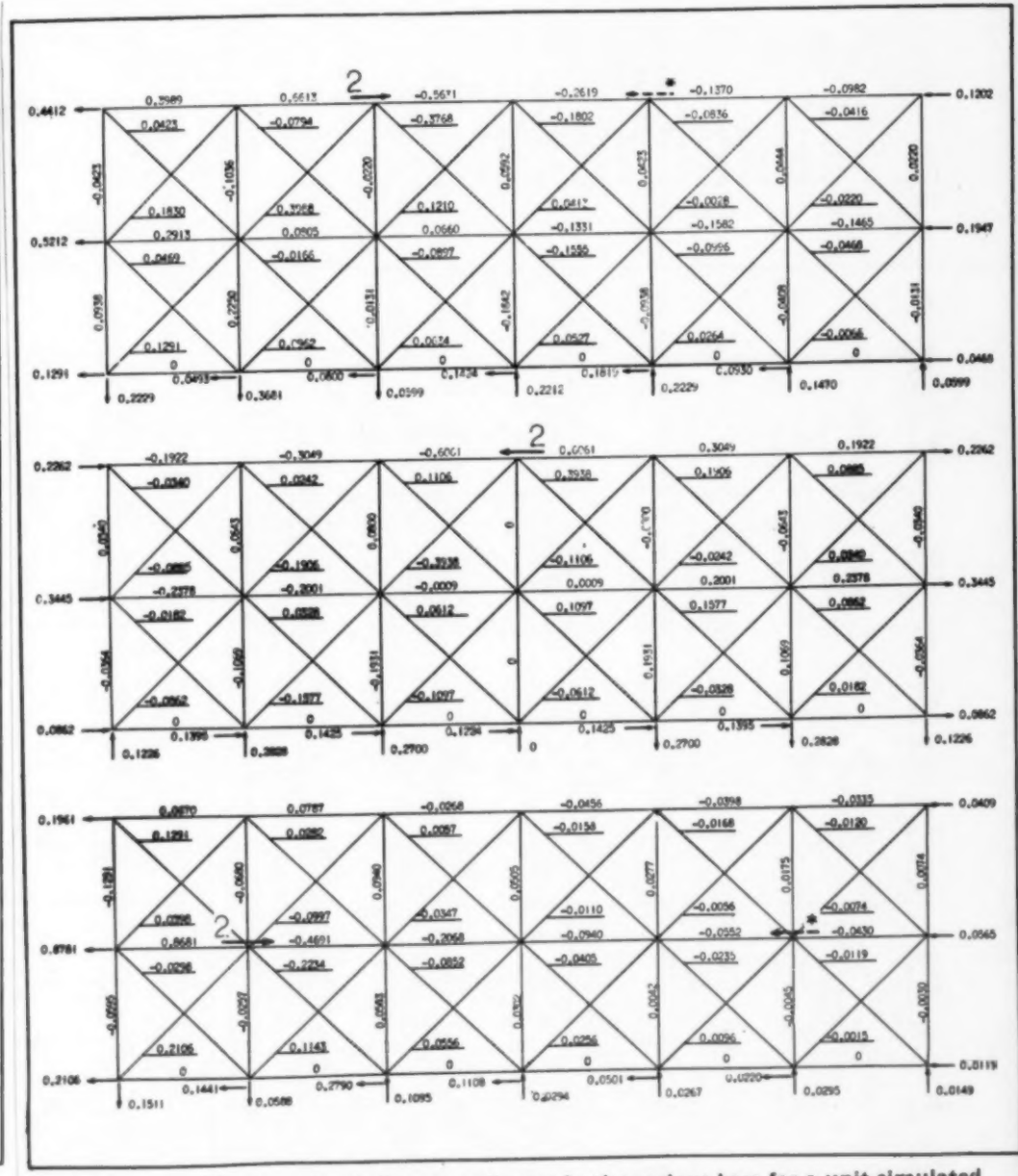


Figure 27 — Diagram gives influence ordinates in the various bars for a unit simulated load of 2 in the panel points shown. If load is applied to the panel indicated by asterisk and dotted arrow, values for stresses will be similar on the corresponding points on the other side of the center of the truss.

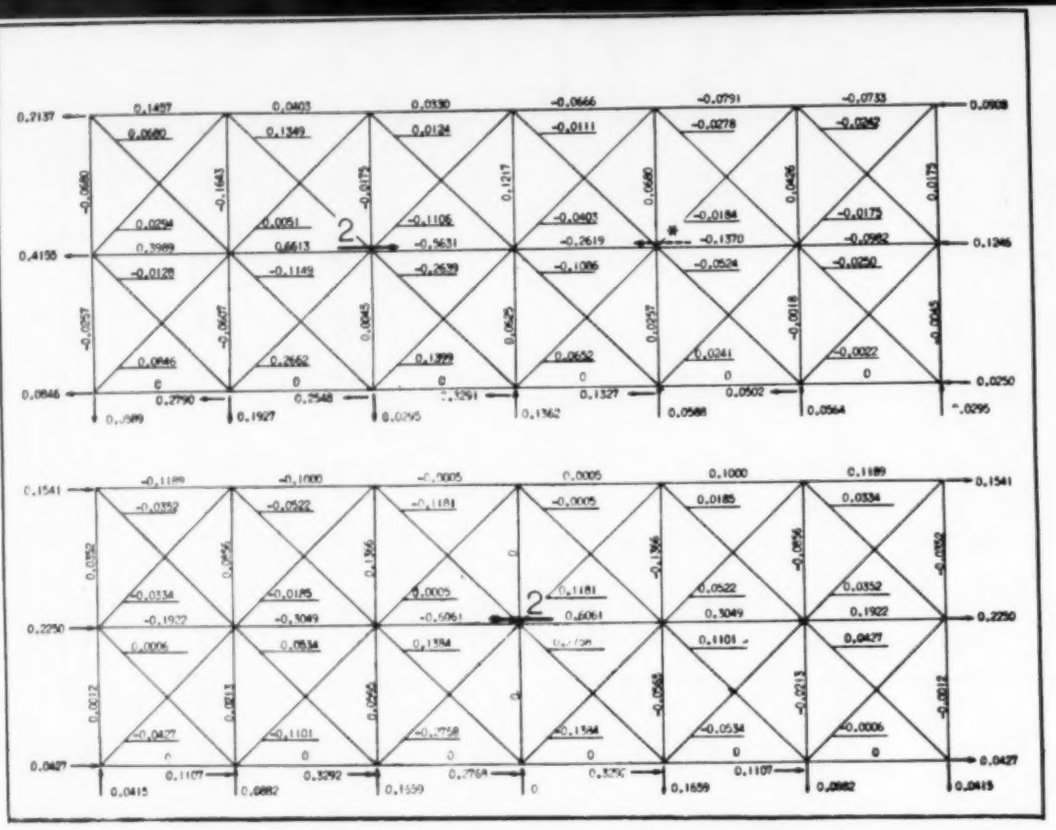


Figure 28 — Diagram gives influence ordinates in the various bars for a unit simulated load of 2 in the panel points shown. If load is applied to the panel indicated by asterisk and dotted arrow, values for stresses will be similar on the corresponding points on the other side of the center of the truss.

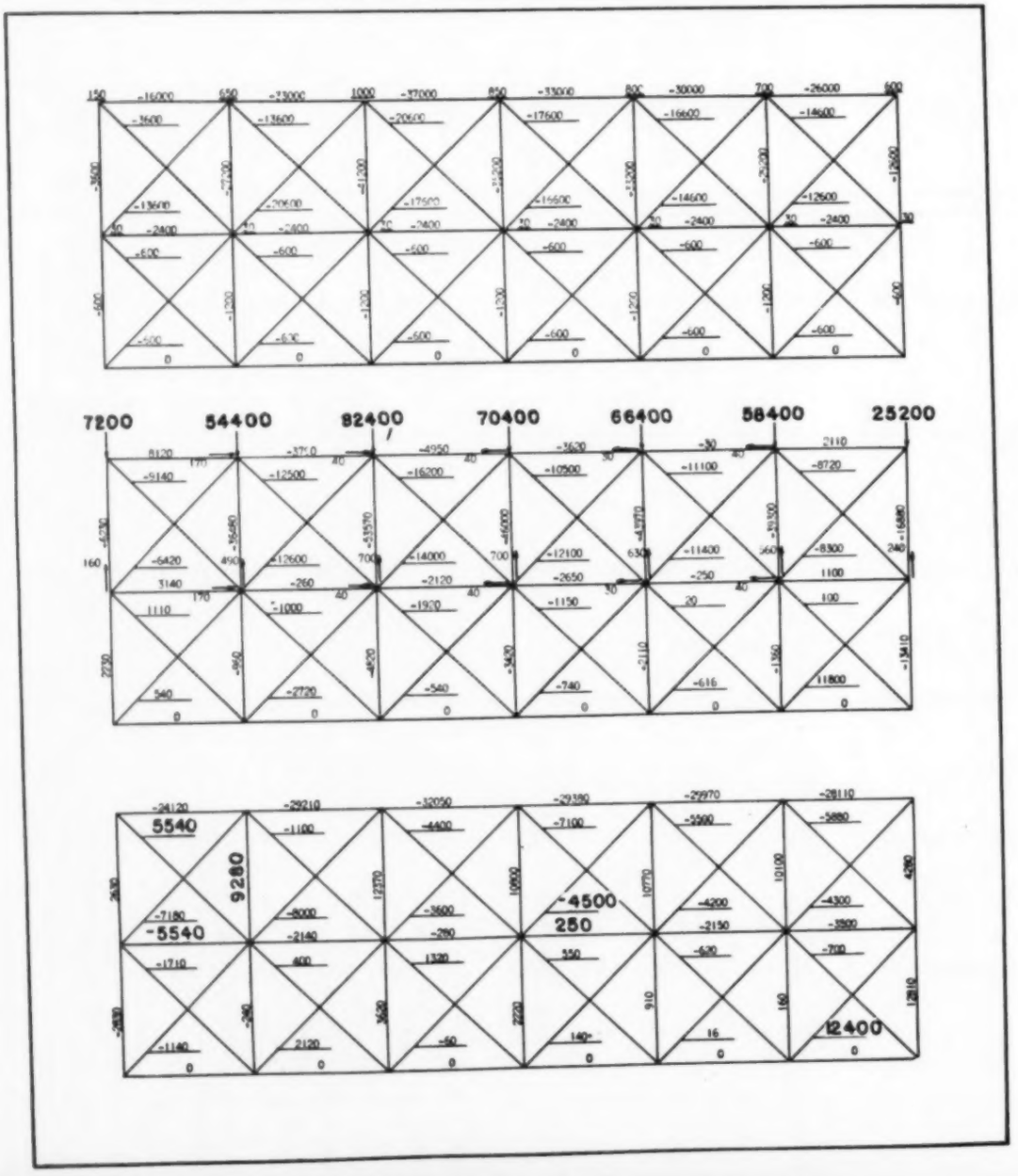


Figure 29 — A sample problem solving for the stresses is given in this diagram. Values were obtained from the influence ordinates given in Figures 24 through 28.

probably as reliable as temperatures measured with instruments presently available.

The analysis based on the computed temperature distribution shows stresses which play an important part in the explanation of spall failures. Cast iron is weak in tension. If the passage of one slab through the mill creates tension stresses of the order of magnitude of 6000 psi, the addition of a small tension stress from some other cause could result in a spall or broken roll.

Although temperature is one of the main contributing factors in the roll failure, it is not the only important factor. What about residual stresses in the rolls? . . . Roll Pressures? . . . "Cobbles"? . . . Cold Steel? . . . The answer to these questions will come after further research.

APPENDIX

LATTICE ANALOGY FOR SOLUTION OF TEMPERATURE STRESSES

The lattice analogy was used for the relaxation of the interacting forces (see Figure 9). In this analog the solid body is replaced by a network of bars. The areas of bars are so proportioned that a force or system of forces of given magnitude will cause the same deformation in the lattice as in the solid body. Therefore the bar stresses, which may be found by any of the common methods of analyzing statically indeterminate structures, are a measure of the stresses in the solid body. Figures 24 through 28 show the bar stresses resulting from forces of 2 units placed at the vertical and horizontal directions at each joint. These influence ordinates makes the determination of the bar stresses for any system of loading a matter of simple arithmetic.

Figure 29 illustrates the procedure used in solving for the stresses due to the temperature gradients shown in Figure 8. Top of Figure 29 shows the temperatures at each joint in the lattice. These values are underlined. The resulting stresses computed from the average temperature in each bar, are also shown. Horizontal and vertical components are given for the stresses in the diagonals.

Middle of Figure 29 shows the unbalanced force at each joint in 100-lb units, and the stresses set up in the lattice by this force system. The influence ordinates shown in Figures 24-28 were used to compute the stresses. As an illustration, look at the upper left chord member in the center of Figure 29 where the bar stress is 8120. This stress is obtained as follows:

$$\frac{8120\times 2}{100} = \begin{aligned}&72\,(-0.1191)+544\,(-0.0257)+824\,(+0.0583)\\&+704\,(+0.0302)+664\,(+0.0042)+584\,(-0.0045)\\&+252\,(-0.0060)-160\,(-0.1887)-490\,(-0.0469)\\&-700\,(+0.0761)-700\,(+0.0403)-630\,(+0.0160)\\&-560\,(+0.0066)-240\,(+0.0044)+170\,(+0.8681)\\&+40\,(+0.3989)+40\,(-0.1922)+30\,(-0.0982)\\&+30\,(-0.0430)+170\,(+0.0670)+40\,(+0.1457)\\&+40\,(-0.1189)+30\,(-0.0733)+40\,(-0.0335)\end{aligned}$$

Bottom of Figure 29 shows the final stresses in the bars. These stresses are a combination of the initial stresses in top and the stresses in the center of Figure 29.

DISCUSSION

PRESENTED BY

J. J. MARSALKA, Technical Director, Roll Manufacturers Institute, Pittsburgh, Pa.

DR. VICTOR PASCHKIS, Technical Director, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

DR. CHARLES F. PECK, JR., Assistant Professor, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

LOUIS MOSES, Mill Engineer, Bethlehem Steel Co., Bethlehem, Pa.

FRED C. T. DANIELS, Vice President, Mackintosh-Hemphill Co., Pittsburgh, Pa.

WADE HOFFMAN, Superintendent Roll Dept., Jones and Laughlin Steel Corp., Aliquippa, Pa.

J. J. Marsalka: The thermal gradient data on hot strip mill work rolls as presented by Dr. Peck is, we believe, a fresh and invigorating approach to this difficult problem of work roll dynamics. After the second year's program has been completed, as Dr. Peck has intimated, it is hoped to present a composite stress picture as applied to hot strip mill work rolls subjected to: (1) temperature gradient stresses, (2) residual roll stresses, and (3) rolling pressure stresses.

All in all, this is an ambitious program. Yet, should the data developed lend itself to the solution of any of the hot strip mill work roll failures experienced, it is worth the energy and effort being expended.

Prof. Victor Paschkis: If I understand correctly, the circumferential heat flow was disregarded in computing temperatures. I wonder if this is permissible. The circumferential heat flow may well be more significant than the radial penetration of heat into the roll. The circumferential roll will cause a pre-heating effect on the incoming part of the roll which contributes to the build-up of temperature in the contact area.

Dr. Charles F. Peck: That is correct. Figure 8 shows that only a shell of one-half inch thickness has been increased in temperature by 90 F or more. If more isotherms had been plotted, say down to 10 F temperature increase, the shell would have been only about 1½ in. thick whereas the circumference of the roll studied is about 85 in. It takes many seconds for the heat to penetrate the 1½-in. shell. Therefore the forward movement of the heat wave during the fraction of a second any point is in contact with the surface will be very small.

Member: There is one thing that I would like to question a little bit, and that is the type of roll that was being analyzed.

The other thing we are interested in is the relation-

ship of temperature to roll failure. Has any attempt been made to determine the critical temperature, or the temperature that is considered critical in regard to roll failure in general.

Mr. Moses reported some observation in the past on the effect of cooling water on the roll, and roll surface, and on the method by which water is introduced on the roll to cool the roll.

Have any further observations been made along these lines. For example, Mr. Moses observed in his previous paper that if the cooling water was applied only on the exit end of the mill, avoiding water on the entry side, he found that it improved the roll conditions considerably.

Dr. Charles F. Peck: In answer to the first question, the type of roll being studied — the general solution is good for any roll whether it be steel or iron. We investigated a chilled iron roll, and we used the constants (K and C) for chilled iron.

In answer to the second question, what is the critical temperature. We are planning in this next year to get actual readings of surface temperatures on rolls. These, of course, can be put back into our general expressions to give a better indication than our assumed surface condition as to what is going on in the roll. From this we can determine if a different surface condition (application of cooling water) would result in lower stresses. Perhaps as Mr. Moses suggests it is better to cool only one side of the roll. We hope to get some of the answers out of this work.

Louis Moses: The AISE has undertaken a study of hot strip mill work-rolls to determine the cause of those unaccountable failures which cannot be ascribed to mill conditions or to known causes otherwise. The Committee assigned to this task is composed of representatives of the steel companies and the roll makers with I. E. Madsen acting directly for the Association. Dr. Peck has been entrusted by the committee to conduct the technical phases of the study wherein he will investigate the influence of temperature gradients on the induced stress distribution in rolls. He will also study the effects of different structural factors which may arise during roll usage and will recount his observations on damaged rolls, etc.

Entering whole-heartedly into his assignment Dr. Peck has been inspired to devise the splendid tool he has just described which is wholly original in concept and application. His paper marks an important step in providing us with a better understanding of how complex stresses are created by temperature variations and shock up to the point of causing failures.

He is careful to tell us that the stated derived values of temperature distribution are not based upon temperatures which are presently known to prevail on roll surfaces. Rather, he provides a method whereby the stresses generated on a roll's surface or within the roll body can be computed from any set of known temperatures.

The difficulties of determining the surface-temperature changes which a roll undergoes is perhaps best illustrated by noting that throughout the whole experience of our industry, there is an almost complete dearth of data. Because of this lack, and particularly applying to four-high hot strip mill work-roll practice, certain methods are being currently developed to determine the desired surface-temperature readings. However, this matter is presently in a more or less experimental stage, with some of the findings rather startling and quite contrary to heretofore held conceptions. This precludes reporting at this time anything other than considerable progress being made to implement Dr. Peck's findings.

Despite the lack of specific information, it is truly remarkable to note the skills which mill operators and rollers display in regulating roll temperatures under the demands of huge tonnage production. The observed action and shape of the emerging strip at each stand is one of the criteria of roll temperature variation during the respective cycles of a roll's installation, but this comes far short of explaining some of the breakage experienced nor does it spell out the causes of spallage.

The cumulative experience with roll usage, grading and selection of roll material, mill techniques, etc., have greatly reduced roll damage when compared with the incidence of damage of say ten years ago. It is hoped that the efforts of this committee, plus the aid of Dr. Peck and his associates, will still further advance the efficiencies of our mills.

Our several companies have unhesitatingly approved this research and provide every encouragement toward making the effort a success.

Fred C. T. Daniels: I will take this opportunity to boost the stock of the members of the Roll Manufacturers Institute, as we too were as much surprised as the roll users when we received the first yearly survey of the service failures of the 4-high hot strip mills, to find that the largest percentage of the failures were breaks through the middle of the bodies of the rolls. These failures were not generally reported to the roll makers as they were evidently considered caused by mill difficulties.

The paper by Dr. Peck brings out the tremendous stresses caused by the rapid heat of the rolls in the mill, stresses up to 70,000 psi tensile. Such a stress is beyond any physical property that we can find in the rolls themselves, and there must be some compensating factor that permits the rolls to hold together. It is obvious any irregularities in the application of heat is most dangerous.

I wish to correct Dr. Peck's statement that the rolls that they examined were chilled iron. This term is applied to rolls with a "definite chill." The rolls were actually of the "indefinite chill" type of a high alloy content.

Dr. Charles F. Peck: Apparently Mr. Daniels misinterpreted the stresses shown in Fig. 11. The stress of 70,000 psi is compressive. The maximum tensile stress is 6000 psi.

Wade Hoffman: I might say that the cooperation the plants have given us on this project has been very beneficial and I do not think that Dr. Peck has mentioned that he has been going into the mills to get information. All the cooperation that has been given him or will be given him will be greatly appreciated by the committee.

USE OF PLASTIC, CASTABLE AND GUNNING MATERIALS IN SOAKING PITS

BY W. D. REES

Superintendent Bar and Blooming Mill

Lowellville Works

Sharon Steel Corp.

Lowellville, Ohio

. . . . plastics and castables are here to stay . . . .

▲ SOAKING pits are of primary concern to the blooming mill operator, and their proper operation, including repairs and maintenance, presents many problems. One problem always present in one form or another is refractories. The extent to which refractories are used in soaking pits makes them rank in importance with the fuel used for heating ingots.

Fired-shape refractories, used for many years in the construction of soaking pits and as a lining for pit covers, have been a source of constant trouble. While difficult of analysis, our particular analysis indicated that:

1. The practice of cooling pits until the brickwork is dark red to black in color for certain grades of stainless steel results in excessive amount of spalling due to thermal shock.
2. Mortar between joints in brickwork gradually deteriorates from thermal and mechanical shock which permits an excessive loss of heat.
3. Joints in brickwork, as the result of mortar deterioration and spalling, are vulnerable to mechanical damage or abuse during the charging and drawing of ingots.
4. Heat loss through joints in cover linings caused damage to different parts of the cover assembly which resulted in excessive repairs and maintenance.
5. Down-time or outage-time on pits off the line for repairs seemed excessive a majority of the time due to the location of the area requiring repairs, the extent of same, and the effect of heat, gas, and smoke on the bricklayers.

These findings indicated that to overcome or eliminate these conditions relative to fired-shape refractories, it was nesessary to:

1. Find a refractory material which would:
   a. Reduce spalling from thermal shock.
   b. Reduce excessive heat loss.
   c. Not be as prone as brick to mechanical damage or abuse.
2. Find a practical and efficient method for performing refractory repairs and maintenance in a much shorter time and with less labor than that required with brick.

Therefore, when we learned that a plastic refractory material was being used experimentally we were very much interested since the claims of the manufacturer regarding its merits coincided with some of the aforementioned objectives which we felt a refractory material would have to meet for soaking pit application.

However, before giving a detailed account of our experience with plastic and other refractory materials, the writer believes that it would be well to briefly describe the soaking pits at the Lowellville Works, Sharon Steel Corp. There are seven banks of pits or a total of twenty-nine holes. The breakdown on these is as follows:

1. Five banks, four holes per bank, arch two-way-producer gas-fired regenerative type pits.
2. One bank, four holes per bank, two-way-producer gas-fired regenerative type pits.
3. One bank, five holes per bank, one-way-oil-fired recuperative type pits.

The dimensions of the pits and covers are as follows:

1. First group:
   a. Pits:
      6 ft 0 in. wide inside dimension.
      10 ft 6 in. long inside dimension.
      9 ft 8 in. deep.

b. Covers:
   11 ft 11 in. long.
   7 ft 0 in. wide.

2. Second group:
   a. Pits:
      6 ft 0 in. wide inside dimension.
      16 ft 0 in. long inside dimension.
      9 ft 8 in. deep
   b. Covers:
      17 ft 6 in long.
      7 ft 0 in. wide.

3. Third group:
   a. Pits:
      6 ft 8 in. wide inside dimension.
      24 ft 6 in long inside dimension.
      12 ft 6 in. deep.
   b. Covers:
      25 ft 1 in. long.
      8 ft 4½ in. wide.

SOAKING PIT COVERS

Initially plastic material was recommended as a lining for soaking pit covers; and since brick linings had always been a source of trouble due to the excessive repairs and maintenance required on them, we did not hesitate to give this material a trial. In September, 1950 we put our first slab-type cover, with a plastic material lining, into service on one of the third group of pits.

Since this first trial we have gradually increased the number of slab-type pit covers in service which have either a plastic or castable material lining. At the present time, we have slab-type covers in service on all of our pits or a total of twenty-nine covers. Twenty-seven of these covers are lined with a plastic material and two are lined with a castable material.

In the year 1951, we put twenty-one slab-type covers, having a plastic material lining, into service on our pits. Twenty of these replaced our sand seal casting-type covers with a brick lining, while one replaced the first cover of this type which we put into service in 1950.

In the year 1952, we put seven slab-type covers, six of which had a plastic lining and one a castable lining, into service on the pits. The installation of these covers made a total of twenty-eight slab-type covers in service. In addition, we took a sand seal casting-type cover and lined it with a plastic material which gave us a total of twenty-eight covers with a plastic lining and one with a castable lining.

In 1953, we put two slab-type covers into service on our pits. One of these has a castable material lining and the other a plastic lining. The cover with the castable lining replaced the only remaining sand seal casting-type cover which was lined with a plastic material. Replacement here was not made due to failure of the lining but due to our desire to completely eliminate sand seal castings because of their cost and their high rate of replacement which was attributable to their oxidation as the result of flame impingement.

Prior to this complete conversion to slab-type pit covers, our covers consisted of channels and beams bolted and riveted together, sand seal castings, and a flat suspended brick lining. In contrast, our slab-type covers now in service are constructed from slabs rolled on our blooming mill, three in. I-beams, and a flat suspended plastic or castable lining which is supported and strengthened by anchor tile evenly spaced and suspended from the three-in. I-beams. These anchor tile are special shape super-duty firebrick. All slabs and beams are welded at joints with no bolts or rivets being used in the entire framework.

A comparison between plastic and castable materials for cover linings on the basis of performance and length of service cannot be made at this time, since our two castable-lined covers have been in service for only a relatively short period. However, on the basis of time and labor required to install a lining, we prefer the castable material which is self evident from Table I.

TABLE I

Installation Data — Plastic and Castable Cover Linings

Data	Plastic material			Castable material	
Sq ft area inside cover	66	99	176	66	99
Crew used to install	6 men	6 men	9 men	3 men	3 men
Actual time required	4 hr	6 hr	12 hr	2 hr	3 hr
Sq ft per man hr	2.75	2.75	1.63	11.0	11.0

Note: Time required for installations does not include preparation or clean-up time.

Castable installations made with cement gun.

A comparison between brick and plastic-lined covers on the basis of performance reveals the following:

1. The average life of our brick linings was from six to nine months while in contrast we have twenty plastic lined covers which have been in service an average of two years.
2. Repair and maintenance was a daily occurrence with brick linings whereas with plastic linings it has been appreciably reduced.
3. With brick linings it was not unusual for the same area to be patched two or three times in a twenty-four hour period. In contrast our present method of patching all cover linings with a castable material shot through a cement gun has given us reasonably good performance and has been effective in reducing outage time on pits.

Although the performance of these plastic lined slab-type covers has been highly satisfactory, we did encounter some difficulties with them which should be mentioned at this time. In the first place, the covers for our third group of pits are 25 ft 1 in. long and 8 ft 4½ in. wide. The long span of these covers makes the lining more susceptible to damage from mechanical shock. It has been our experience that damage from mechanical shock to these particular linings is confined mainly to the front portion of the cover. We feel that the damage is localized in this area due to the following:

1. The front end of the slab framework being pumped by ingots during charging and drawing of pits.

2. The front end of the slab framework being bumped by the coke box when dumping coke breeze during the making of bottoms.
3. The swinging action of these covers during opening and closing caused by the limit stop switch cutting in and bringing the cover to an abrupt stop.

In view of this experience with lining failure due to mechanical shock or abuse, we felt that all the strength and support possible should be provided the lining for a cover with this length span. Therefore, we developed by trial and error the following changes in the design of the slab framework:

1. Extended side slabs, which run lengthwise, two in. below the slabs in the front and back ends of the framework.
2. Welded a one-in. square billet around the inside perimeter of the slab framework two in. up from the bottom edge of the end slabs.

It should be noted here that of the five covers in service on the third pit group, all of which have the aforementioned design changes in their slab framework, four of them have been in service for two years. The fifth cover has only been in service since April of this year and is the third one of its type to be put into service on this particular pit. However, it should be pointed out that the first two covers did not have the aforementioned design changes incorporated in their slab framework. In addition, we were using the cover installations on this particular pit as a test to determine if a cover of this size and of this type was practical.

Secondly, on a row of the first pit group, the covers for which are 11 ft 11 in. long and 7 ft 0 in. wide, we decided to incorporate a "peep hole" in the front center portion of the plastic material lining. The sharp angle of the "peep hole," which was necessary in order that all ingots in the pit could be seen, created a definite weak spot in the cover lining. As a result, we experienced lining failure in this area due to mechanical and thermal shock. It has not been necessary to replace the complete lining of these covers, but when actual repairs were required we eliminated the "peep hole."

Third, we found that plastic linings must be carefully rammed particularly in the final stages. It is at this point that you have minimum clearance between the slab framework and the material that has been rammed. Failure to get proper and careful ramming in this area of the cover lining results in excessive sloughing off of the lining after the cover has been in service a short time.

Finally, we found that failure to properly "burn in" a new cover lining before steel is charged in the pit for normal heating resulted in excessive sloughing off of the lining around the perimeter of the cover. To overcome this, we resorted to the practice of leaving the cover raised off the pit coping and fired the pit with a low to moderate flame for at least eight hours before charging ingots.

PIT COPINGS AND WALLS

a. *Copings*—The satisfactory performance of plastic material linings in our slab-type pit covers made us willing to experiment with it on a coping. Thus in October, 1951, we installed our first plastic coping on a division wall between two of our first pit group. This coping was in service until June, 1953 at which time this particular row of pits was torn down for a complete rebuild. During this rebuild, plastic material copings were installed on all walls.

Based on the performance of plastic material on this first coping, we decided to install plastic material copings on all walls when pits were completely rebuilt. During the years of 1952 and 1953 respectively, we completely rebuilt three rows of the first pit group and the second pit group installing plastic material copings on all walls. In 1953 we also rebuilt one of the third pit groups, and installed plastic copings on all walls. The average installation time required on our plastic copings has been eight to ten hours which is equivalent to 1.5 to 2.0 cu ft per man hour.

These copings are still in service and eliminating serious mechanical damage or abuse, we have no reason to believe that we will encounter failures. As compared with brick, these copings seem to withstand mechanical and thermal shock much better and have required very little repair and maintenance. However, it should be noted here that we have observed a slight erosion of these copings, but not in any sizable proportion so as to give us cause for concern. We believe that this condition is caused by ingots rubbing against the coping during the charging and drawing of pits.

b. *Walls*—Our favorable experience with plastic material applications in cover linings and copings made us feel that the potential was very good for extending this application to soaking pit walls. The second pit group was selected for this experimental application since the entire row was scheduled for a complete rebuild. In January, 1953, we installed our first soaking pit wall of plastic material.

Due to the moisture content of the plastic material, the vendor recommended that we provide horizontal and vertical vent holes in the wall. For the horizontal vent holes, we made some ½-in. rods, having a handle on one end and a sharp point on the other end, approximately 18 in. long. For the vertical vent holes we made some ¾ in. rods similar to the ones for the horizontal vent holes, but these were approximately 10 ft 6 in. long. All vent holes were staggered and were approximately 18 in. apart. In addition, we made sure that the horizontal and vertical vent holes overlapped one another but never intersected.

When the wall was completed, we started wood fires in the pits on each side for the purpose of drying any moisture in the wall. We kept the wood fires burning for a period of thirty-six hours after which we fired with natural gas to finish the drying out. Approximately four to six hours after the natural gas firing was started we discovered that a portion of the wall had fallen in. The location of this failure was in approximately the lower center part of the wall. After inspecting the wall at the point of failure, and noticing that the remainder was still in its original position, we decided that the area where failure had occurred was too large to permit saitsfactory repair and that the wall should be torn down and rebuilt.

It was agreed that during the second installation and drying out, we would proceed as follows:

1. Provide more vent holes.
2. Use 1½- in. rods tapering down to 1 in. for vertical vent holes.
3. Use ½-in.rods tapering down to ⅜ in. for horizontal vent holes.
4. Take a longer period for wood firing.
5. Complete the drying out with producer gas instead of natural gas.
6. Make periodic observations of the vertical vent holes checking on moisture escape and the extent to which the wall was drying out.

The installation time required for this wall was twelve hours which is equivalent to 1.5 cubic feet per manhour. This division wall is still in service and although both faces of it are rough in appearance due to small chunks being knocked off by ingots, it has not shown any signs of failure to date.

In February, 1953, an outside wall of one of our first pit groups bulged, and it was evident that it would have to be torn down and completely rebuilt. We felt that this presented an excellent opportunity for us to install a castable material wall as well as establish a basis of comparison between plastic and castable materials for this type of application. For this installation we used a cement mixer and a twenty man crew. The total installation time was two and one-half hours which is equivalent to 3.0 cubic feet per manhour.

In April, 1953, we completely rebuilt an outside pit in our third group. We installed the outside wall and the front and back walls with castable material, while for the division wall we used brick and stone. In the front and back walls respectively, we blocked off areas 3 in. square and approximately 36 by 40 in. with wooden forms, prior to pouring the castable material, in order that we could ram plastic material around the thermocouple well and the burner port. The same method as was used in the installation of our first castable wall and a twenty-man crew were employed in the pouring of these three walls. The total installation time was five and one-half hours which is equivalent to 4.5 cubic feet per manhour.

In June, 1953, we scheduled a row of our first pit group for complete rebuild. Since our limited experience with castable walls had been satisfactory up to this point, and since we were interested in finding out how far we could go in using castable material in soaking pits, we decided to install all walls, bottoms, and arches of this row with a castable material. Having made this decision we set up the following plan for this installation.

1. Pre-fabricate all wooden forms required for the pouring of bottoms and walls.
2. Install clean out hole forms and completely seal up cracks or openings in bottom plates and castings.
3. Pour bottoms.
4. Install arch forms and pre-fabricated wall forms after bottoms are set up.
5. Ram plastic material copings on walls after they are set up.
6. Pour arches.

For this installation we used two cement mixers to pour the bottoms, walls, and arches. The total time required for the castable installations was eighteen hours while eight hours were required to install the plastic copings. This is a total of twenty-six hours required for the castable and plastic installations which represents 837 manhours and is equivalent to 4.0 cubic feet per manhour.

A comparison of the total manhours required to rebuild this row of pits with the average manhours required to rebuild four other rows of the first group, where brick and stone were used entirely except for the plastic copings on two rows, reveals that 9774½ manhours were required for this rebuild as compared with 13,695 average manhours required per row for the rebuilding of four rows of pits. This is a reduction of 3920½ manhours or 28.6 per cent.

In July, 1953, we had to tear down two outside walls and dig out a bottom in a row of the first pit group. Here again we decided to use castable material instead of brick for the rebuilding. For these installations we used one cement mixer and a crew of twenty men. The total time required for these installations was five and one-half hours which represents one hundred and ten manhours and is equivalent to 5.25 cubic feet per manhour.

At this time the installations using castable material have not been in service for a long enough period to make an accurate determination of their performance. We feel that both our plastic and castable installations must be in service for at least one year before a fair basis of comparison can be established between plastic, castable, and brick.

REPAIRS AND MAINTENANCE

When the manufacturer, from whom we were purchasing plastic and castable materials for our cover linings, copings, and walls, recommended the use of a cement gun for performing repairs to refractories we were very much interested. After observing this operation in another steel plant, where a cement gun and plastic material were being used for repairing and maintaining soaking pits, we adopted this method for use in our plant.

The gun we purchased is a standard type cement gun widely used in the steel industry today. This gun was delivered to us in December, 1951, and by January, 1952, we were using it for the major part of our repairs and maintenance.

We use a crew of three men (one operator and two helpers) to operate this gun and perform the necessary repair and maintenance work on our soaking pits. The normal work schedule for this crew is a five-day, forty-hour week.

At the present time we are using both castable material and plastic material in the dry form in the gun. The castable material is used for cover patching only while the plastic material is used for repair and maintenance of our copings and walls.

Having had approximately two years experience with this method of performing refractory repair and maintenance, we believe that it is most effective in re-

ducing outage time on pits and has produced economies in our soaking pit operations. Evidence of economies realized is shown in Table II.

TABLE II

Refractory Repair and Maintenance Cost per Ton of Production

Year	Labor cost per ton	Material cost per ton	Total cost per ton
1951	$0.077	$0.080	$0.157
1952	$0.050	$0.046	$0.096

SUMMARY

In conclusion, we are convinced that the proper application of these materials, as discussed in this paper, is an important factor in the increased efficiency of our soaking pits and in the improved performance of our mill. Tables III, IV and V are the proof of this.

TABLE III

Average Heating Delay Time per Month

Year	Hours
1951	13.0
1952	7.2
1953 (Six months)	6.3

TABLE IV

Gas Coal Consumption and Btu per Ton of Production

Year	Lb coal per ton	Btu per ton
1951	137.5	1,774,163
1952	119.6	1,562,574
1953 (Six months)	105.1	1,400,983

TABLE V

Average Ton per Hour — 34-in. Blooming Mill

Year	Tons per hour
1951	66.4
1952	71.5
1953 (Six months)	73.7

We are satisfied in our own minds that there are additional economies realized in our soaking pit operations many of which are hidden. Also worthy of note is the fact that we have eliminated our inventory of sand seal castings which approximated $20,000.

The performance of these materials in our soaking pits has resulted in their being tried in other departments where successful applications have been found for them in slab annealing furnaces, hot metal ladles, hot metal spouts, and slab reheating furnaces.

Finally, on the basis of the applications discussed in this paper we feel that these materials have established themselves as being practical and economical for additional applications in the steel industry.

DISCUSSION

PRESENTED BY

C. W. THOMPSON, Ceramic Engineer, Bethlehem Steel Co., Johnstown, Pa.

W. D. REES, Superintendent Bar and Blooming Mill, Lowellville Works, Sharon Steel Corp., Lowellville, Ohio.

BAIRD L. DORSEY, Refractories Engineer, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

JAMES D. McCULLOUGH, Chief Engineer, Refractories Div., Babcock and Wilcox Co., New York, N. Y.

R. M. RICHARDSON, District Manager, The Ramtite Co., Pittsburgh, Pa.

JAMES KNIVETON, Vice President, Selas Corp. of America, Philadelphia, Pa.

C. W. Thompson: During the past several years there has been a renewed interest in castable and plastic refractory materials with reports of numerous applications being presented at each meeting. It is, I believe, generally understoood that these are special materials and not intended or economically suited for routine replacement of normal brick construction. Justifiable installations vary from plant to plant dependent upon service conditions and economics at the plant. Mr. Rees has apparently found such an application for his plant and is to be complimented on the work they have done and his very able description of that work as presented to us in his paper.

Any installation of refractories in a steel plant must be economically justified. The cost of materials alone when installing these special refractories to replace normal arch or straight wall construction is approximately 2½ to 3 times that of firebrick. This additional material cost must be off-set by (1) a more rapid installation (reduction in furnace down time), (2) a reduction in labor cost by faster installation or through the use of unskilled labor, and (3) by greater service life. The importance of each of these factors is greatly affected by conditions particular to the individual plant. During this period of maximum production these materials, installed by non-skilled labor, have made it possible for those shops having a limited number of bricklayers to keep their furnaces in production. Some of these installations undoubtedly could not be justified where skilled crews of bricklayers are available. On the other hand more severe service conditions because of the "press" for maximum production has created places where these materials will give better service because of improved resistance to spalling.

We at Johnstown have not made extensive use of these special refractories, however, we do have several

experimental installations in service. Of particular interest to us are applications where precast sections may be used, where expensive bricklayer hours can be reduced in areas of considerable "cutting and fitting" and in particularly troublesome spots where service conditions indicate that superior life might be expected from these materials.

With particular reference to soaking pits our only application of these materials there has been for burner blocks and the area around the bottom "cleanout" hole. Our 46-in. mill soaking pits consist of 30 holes of one-way fired recuperative pits. The pits have been in operation approximately two and one-half years with only minor patching of the walls and only four of the sprung arch covers have been removed for minor patching. Routine replacement of the coping tile has been necessary with failure being attributed primarily to mechanical abuse.

I note from this paper that wood fires are used for drying-out and heating up these pits. We have found that the use of gas with suitable auxiliary burners provides a much more satisfactory method of drying-out or heating-up any type furnace. The advantages being a more even and more easily controlled heating rate and the elimination of high concentrations of alkalies from the wood ash which are particularly harmful to any refractories.

I trust that Mr. Rees will present a sequel to this paper when sufficient service life is obtained on their cast pits, and that he will include comparative installation and maintenance cost of the cast material versus normal construction. Included in these costs, of course, would be the necessary labor and forming materials for the cast installation.

W. D. Rees: I again call attention to the various applications where we have successfully used plastic, castable, and gunning materials at Sharon Steel Corp. —soaking pit covers, copings, and walls, hot metal spouts, slab re-heating furnaces, and slab annealing furnaces. In addition, I direct your attention to the fact that successful applications have been found for plastic materials in hot metal ladles, open hearth steel runners, and open hearth checker roofs. Therefore, on the basis of these facts I believe that we can no longer consider these materials as strictly specialty items since they have been found to be economically suited for routine replacement of normal brick construction.

The question arises, relative to the justification of using these materials where skilled crews of bricklayers are available, as to the number of skilled artisans the various steel plants have in their employ today for laying brick? From our experience, and the unconfirmed reports one hears regarding skilled bricklayers in other plants, it would seem that this type of labor is the exception rather than the rule. A plaŭsible explanation for the shortage of this type of skilled labor is the surge in residential and commercial construction which this country has experienced since the end of World War II. This tremendous growth in construction has resulted in contractors paying attractive hourly rates for skilled bricklayers and in skilled bricklayers starting their own contracting business.

Baird L. Dorsey: Mr. Rees has presented an interesting and, as far as his experience has gone, a complete picture which is very favorable to the use of specialty refractories in soaking pit construction and maintenance.

I have found it very difficult to evaluate experiences between plants with any degree of accuracy. The local conditions found far outweigh the change in the form of the refractories used. Further, when these changes in form of refractories used are made, more attention is given which in itself results in getting all concerned to do his job better.

Another factor, often overlooked in the success of these forms of refractories for pit covers, is the all new cover frames or the supported construction generally used. The slab type frames are more rigid and their heavier construction resists the normal abuse that occurs in operations.

J&L's first experience with slab cover frames was in 1939 on small producer gas fired regenerative pits. These replaced the then conventional cast iron frame of four sides bolted together in which a sprung fireclay brick arch was used. The slab frames were lined with suspended firebrick construction and shortly afterward semi-silica brick shapes replaced the fireclay brick. The larger recuperative pits firing mixed gas started using slab frames for replacement in 1945 and to the present time all frames have not been replaced.

All types of construction and kinds of refractories are used in the slab frames. Where thermal spalling of fireclay brick has been a factor in service life, plastics, castables and semi-silica brick have shown definite improvements. The economies of the various types and kinds of installations is what will finally determine which refractory form is best.

If I interpret Mr. Rees' paper correctly, he has completely rebuilt 5 of the 7 rows of pits in the 1½ years, 1952 through July, 1953, plus replacing 4 outside walls and conducting his normal shooting maintenance. This seems like a very high percentage replacement and I would question the fault as being all refractories.

The mention made of a trial rammed division wall made me look back in some obsolete prints of soaking pit construction. These prints revised in 1914 showed rammed gannister and clay walls, further checking determined that the rammed construction was superseded by brick construction in 1924 when pits were enlarged. The vent holes you placed in your trial rammed wall may afford a plane of weakness and cause early failure by slabbing off. Further, if you use sand for sealing, this will flow into these vertical openings and push the wall apart unless your average wall temperature is very low.

The castable outside walls are undoubtedly anchored so the problem of bulging should be solved, but these same ties or anchors in stone or brick construction accomplish the same end.

Maintenance of copings by shooting has been practiced at our plants since the early 1930's. It has only been in recent years that some purchased shooting refractories have been used. We have made our own by crushing used clay brick bats, adding clay and a flux (generally salt), which is relatively inexpensive and

Figure 1 — Illustration shows a cover after being in service for four months on which was installed a test castable material.

Figure 2 — Picture of cover shown here was taken after three weeks service.

accomplished the same purpose as long as equipment and manpower to do this were available.

The installation of new copings using plastics and castables would prove economical in cases where large high extra coping shapes are replaced. However, where standard size bricks are used for copings and the sand troughs grouted with an air setting cement, or like material to prevent the sand used for seal from working down in joints and loosening the brickwork, the same gains are had at much lower cost. Servicewise, mechanical abuse by charging and drawing ingots is just as destructive to each kind of refractory.

The following three illustrations show trial applications of the specialty type refractories after service and behavior of these forms compared to brick.

Figure 1 shows a refractory brick, semi-silica cover, in which was installed a test castable material. This looks like it has been through the war, but it has only been in service 132 days. There are three to four inches of this castable gone, in this three months' service. The semi-silica brick adjacent are still full size.

Figure 2 shows a cover which was only in service for three weeks. This is also a castable material in one end. At this time, we found this particular corner section had dropped out, so it was taken off and patched, and at that time we put this two-inch shelf, welded to the frame to try and hold the castable material. Then due to another accident in which the cover was taken off in another month for center part replacement, while it was up on the rack we took a look at this condition, and we saw that it was deteriorating the same way, so that was not the answer to that problem. I think that is one problem we have to solve on the castables.

Figure 3 shows the typical slabbing off that occurs with plastics. This happens to be a boiler nose with slabs off in that area. There are the brick standing out with all the adjacent material gone.

W. D. Rees: It is true that operating conditions vary from plant to plant in the steel industry. However, it must be recognized that the numerous processes required in the making, shaping, and treating of steel are fundamentally the same in all plants. Therefore, if correct, reliable, and sufficient data can be obtained from various plants, relative to a specific phase of steelmaking or processing, it would seem that proper correlation of such information, including the variables, furnishes the basis for evaluating operating experiences from plant to plant with a fair degree of accuracy.

The fact that a change has been made in the form of refractory being used does not necessarily mean that all concerned will give the new refractory more attention than the old and do their respective jobs better. It seems that you can always find people in every organization who are reluctant to try that which is new or a variation from long standing practice or procedure. These individuals are prone to criticize before the new is given a fair trial, are not particularly interested in whether it succeeds or fails, and are quick to say, "I told you so" if failure does occur after a fair trial. Therefore, we often find that it is the job of one or a few individuals, under handicap, to prove the merits and value of a new product, process, or procedure.

It must be recognized that slab-type frames for soak-

Figure 3 — View shows 4-in. spall the width of boiler on a plastic lower arch installed in June 1950 and patched in April 1951. Picture was taken on February 26, 1952.

ing pit cover linings afford a rigid construction which is not so susceptible to mechanical damage or abuse. However, it must also be recognized that the construction of the cover framework does not govern the spalling of the refractory lining due to thermal shock.

It should be pointed out that of the five rows of soaking pits we completely rebuilt within the short span of eighteen months to two years all of them were in service for an average of five years.

Relative to mechanical abuse caused by the charging and drawing of ingots, it is questionable in my mind as to whether this abuse is equally destructive to each type of refractory. It would seem that the joints in the brickwork, due to mortar deterioration, resulting from mechanical and thermal shock, and to the outer surface or face of the brickwork spalling from thermal shock, present much more of a target for mechanical abuse than a monolithic structure.

James D. McCullough: Our observations bear out the advantages of castables over plastics in many types of applications. We have observed the same points brought out by Mr. Rees, that there is (a) greater speed of application, (b) lower labor cost, (c) elimination of critical firing-in, and (d) elimination of venting.

Although Mr. Rees does not have the comparative life data of his plastic covers versus the castable covers, because his castable covers are of relatively recent origin, we have records of several covers installed in the same month as his initial plastic cover, namely, September, 1950. The plant where these covers are installed had a similar operating experience with fire brick lined covers, as did Mr. Rees in his plant. Those castable covers are still in service, and as yet there has been no maintenance on them.

We were interested in the description as to the widespread use of the plastic copings, even to the extent of using the plastic on the castable walls. Therefore, I would like to ask Mr. Rees several questions:

First, has he tried castables in the copings? If so, what has been the experience?

Second, what method, if any, was used in anchoring the copings?

Third, what has he found to be the most satisfactory height of the coping?

Fourth, what wall thicknesses were used?

We are also interested in his comment that the castable covers have been installed by gunning methods. Some initial covers that were gunned some time ago, with which we are familiar, were installed by turning the cover upside down, installing forms around the anchor tile, and gunning against the form.

More recently we have been familiar with covers up to 17 feet by 20 feet, successfully gunned from the top through the various structural steel members. Would Mr. Rees inform us as to whether he gunned his covers from the top or from the bottom?

W. D. Rees: We have one castable material wall which extends from the slag line to the top level of the pit. This wall, which is an outside wall in one of our first group of pits, was poured in February of this year and was our first installation of castable material for this particular application. We have noticed a slight chipping or sloughing of the castable material at the coping level, but do not believe that we have had sufficient service experience at this time to accurately determine which type of refractory material is best suited for copings.

The majority of our copings are of plastic material and no means for anchoring them was provided in our castable material walls. However, on our walls of fired shape construction which have plastic material copings, we provided a key-way, in the center of and running the entire length of the wall, for anchoring the plastic material.

Relative to the height of our plastic material copings, it should be pointed out that we did not establish any definite measurement but felt that twelve inches should be the minimum. Our coping height ranges from 14½ to 16 inches. The thickness of the walls on our first group of pits is 27 inches, on our second group is 31½ inches, and on our third group of pits, is 36 inches.

All castable material cover linings we now have in service were installed from the bottom side of the cover by turning the cover upside down.

R. M. Richardson: The paper just presented by Mr. Rees was a very clear, concise and honest report of service and costs of installations of plastics, castables and gunning materials in their steel works. He did not pick out a particular installation that failed to give good service, then make a few remarks and call it a day.

He collected factual information on installations of the several materials, hewed to the line and let the chips fall where they may. He is to be congratulated on a good thorough job.

The first of our rammed soaking pit covers installed in the Pittsburgh territory was in July, 1947. It is still in service with only one small repair (12 x 18-in.) made in the fifth year and after 6½ years it looks like it will last a number of months longer.

Other of our covers here have been in service 5 years, 4 years, 3 years, 2 years, 1 year and a few months.

All covers, with the following exceptions, are in excellent condition. Very few repairs have been necessary over the years, except damage to the materials in a few cases when renewing sand seal castings.

One cover, which was installed in December was frozen before it was put on the pit and was replaced. Another cover installed in 1950 was completely rebuilt just recently. This was one of those cases where trouble developed and nobody knows how, when or why.

Also, a number of castable covers are in service, the first was installed in July, 1950. The second was put in service in September, 1950 and the third in January, 1951.

These covers, two with over three years of service, are still operating and in good condition. Additional castable covers were installed during 1952 and 1953.

It is true that trouble did develop with one or two of the castable covers during the period of experimentation, however, the covers now in service are in good condition. They are over hot pits and a castable that will stand up under these operating conditions cannot be a garden variety of material.

Other installations by use have been made on side walls, roofs and burner walls in the heating and soaking zones of double and triple fired billet and slab heating furnaces and on a number of forge furnaces, railroad spike furnaces, checker roofs, fan tails and noses in the open hearth, and, last but not least several dutch oven arches under large boilers.

Plastic refractories have many advantages besides lasting longer in service. Because of high insulating value, fuel reductions as high as 20 per cent have been accomplished in furnaces over the previous record made with fired shapes. Product production has increased as much as 25 per cent.

Plastics and castables are here to stay. Their use in steel mill furnaces is showing a tremendous increase. Today plastics, castables and gunning materials are compounded as scientifically as are fired shapes. Their quality is as good or better and over the next five years use of these materials will extend into services not now contemplated.

W. D. Rees: On the basis of the successful applications of plastic and castable materials in the steel industry which have been discussed here I concur with Mr. Richardson's statement "Plastics and castables are here to stay." It is my sincere belief that these materials can no longer be thought of as an incubator baby whose grip on life is by a thin thread. Rather we must consider them as a normal, healthy, and growing infant who will reach adolescence.

James Kniveton: Mr. Rees presents some facts and figures that should be helpful to the steel mills. Some he expresses in dollars and cents, others in labor, which can of course be related to dollars, and in which everyone is interested, especially in respect to operating costs.

I cannot talk from the standpoint of a soaking pit operator, but we have used castable materials in some of our furnaces with very favorable results.

Mr. Rees refers to brick linings that are patched sometimes two or three times in a 24-hour period. Now, in contrast to this, the present method is to patch linings with a castable shot through a gun. I would like to know, is this hot patching, or is the cover cold when the patching is done?

If it is done hot, do you get a good bond between the old material and the patching material?

Has the ramming material ever been tried for patching?

Mr. Rees also comments that plastic linings must be carefully rammed, particularly in the final stages. Possibly this may account for some of the additional installation costs for rammed material.

If hand-rammed, have you experienced any difference in the finished job if the ramming is done at the beginning of a shift, say, when a man may be strong, and sections rammed at the end of a shift when, possibly, the man's energy has been diminished?

Referring to the failures due to improper burn-in, I would judge some expansion joints have been used in the construction.

Some of the interesting figures refer to cubic feet per manhour. I do not know how many brick the present day bricklayer will lay per eight-hour day in a steel mill. I suppose that would vary considerably from plant to plant, and the quality of the bricklayer; but if we think of a bricklayer laying 400, on the average, brick a day, which is about 50 brick per hour, this is equivalent to about three cubic feet of brick laid per hour, if they are doing that.

There is one plastic reference to 1½ cubic feet per hour, while reference is made to some of the castable work as being from three to five and a quarter cubic feet per hour, which is equivalent and better, in a couple of cases, than what can be done by a bricklayer, if we think of a bricklayer in terms of about 400 bricks average per day.

Reference to a bricklayer laying 400 bricks per day does not include a helper. Required helpers will vary according to the job at hand and the number of bricklayers used. It is conceivable, with helpers included, the 400 bricks layed per bricklayer could be reduced to 200 to 250 brick per man day, in which case the previous comparison for castable work could become more favorable.

The relationship could be about 25 brick per manhour, equivalent to 1½ cubic feet of brick per manhour, as against 3 to 5¼ cubic feet of castable per manhour.

W. D. Rees: The majority of the refractory repairs required on our cover linings involves hot patching. However, there are cases where the repairs required are extensive and necessitate the performance of other work prior to the actual patching thus making the repairs a cold patching operation.

Hot patching the linings of our soaking pit covers has given us favorable results up to the present time. Therefore, I must assume that we get a fairly good bond between the old material and the patching material.

Up to the present time we have only used a castable refractory for patching cover linings. However, the use of a plastic material for this application is under consideration at the present time.

Experience has taught us that eight hours is the maximum time any one group of men should ram plastic material if proper installation is to be obtained on the entire job.

We do not use expansion joints in the construction of our slab-type soaking pit covers.

There has been much discussion here today relative to the merits of fired-shape refractories versus plastic and castable refractories for soaking pit application. It is my humble opinion that to accurately determine which type of refractory material is best suited for this application requires that:

1. The refractory materials discussed be submitted to a fair and equal trial under all service conditions.
2. All information pertaining to the trial of these materials, along with other pertinent data, be collected and accurately recorded.
3. This information and data be the sole basis for evaluation and comparison.

SYSTEM ENGINEERING
FOR
CONTINUOUS STRIP PROCESSING LINES

By J. S. APPERSON
Steel Mill Engineering
Industrial Engineering Section
General Electric Co.
Schenectady, N. Y.

. . . . the day is approaching when the entire cold finishing process will be one continuous operation from the pickle line to the tinplate pilers . . . .

▲ STRIP processing lines have come of age and require the same system engineering approach in their design and layout as do tandem cold strip mills, continuous hot strip mills and large reversing blooming and slabbing mills. The trend in the steel industry to combine more and more strip processing operations into continuous processes requires that highly specialized engineering skills be applied to the problems of coordinating the various phases of these lines into one smooth working facility. New products and equipments have been developed to solve the special problems created by the continuous production philosophy, and careful attention to all components of the installation are necessary to insure uninterrupted production.

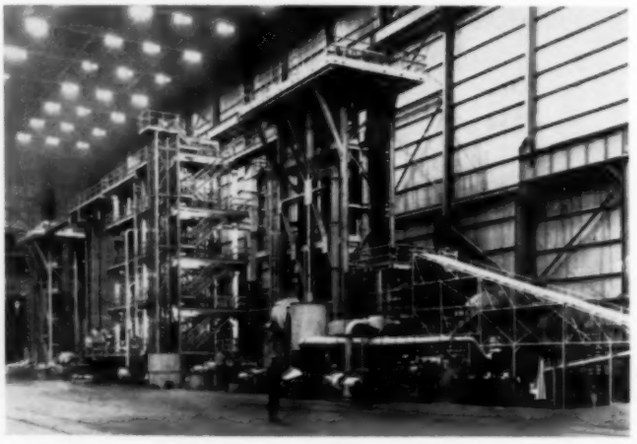
To achieve the final desired results on one of these continuous strip processing lines, the cooperative efforts of many highly skilled engineers representing widely divergent backgrounds are required. Much could and should be written of the importance of the engineers at the steel plant. Theirs is the roll of interpreter and guide to see that the desires of "operations" are properly interpreted and new ideas are properly evaluated so that all members of the team work together to achieve the final results.

The machinery manufacturer's engineers play an important role. They bring into focus on a particular problem a wide background of experience in machinery processes and equipment, plus a clear analytical mind and forward thinking. The construction engineer contributes much with his knowledge of installation cost and construction practices.

This paper is limited to electrical system engineering for continuous strip processing lines, but the author wishes to emphasize the important contributions of the many talents that have gone together to make these marvels of modern engineering achievement a reality.

Certainly the continuous tinplate annealing line (Figure 1) designed to anneal tinplate strip at 1000 fpm and 30 tons per hour is no mere collection of pieces. It was only as the result of complete system engineering that this imposing installation came into being. A total of 150 motors both a-c and d-c, totaling 1662 hp, with 9 generators and 12 associated booster generators, are used on this line. A total of 20 modern feedback

Figure 1 — Continuous tinplate annealing line has rated capacity of 30 tons per hour at 1000 fpm.



control systems are employed and each was analyzed to check not only its own performance but its performance in relation to other parts of the system.

Besides the strip propelling equipment and the many specialized electrical tools used to control and monitor the operation, the furnace was supplied by the electrical manufacturer and included 925 kva of electrical resistance heating capacity in the controlled cooling section. The scope of the electrical system engineering included all phases of power supply from the high voltage incoming power lines through the various unit substations, items of metal clad switchgear and motor control centers, down to the smallest motors, solenoid valves and other miscellaneous power requirements.

It is interesting to note that although this annealing furnace is heated with both gas and electric power, the electrical industry has had considerable experience with all electric furnaces of this same general type, and the industry stands prepared to build an all electric furnace for tinplate annealing should the economics of fuel costs dictate such a need.

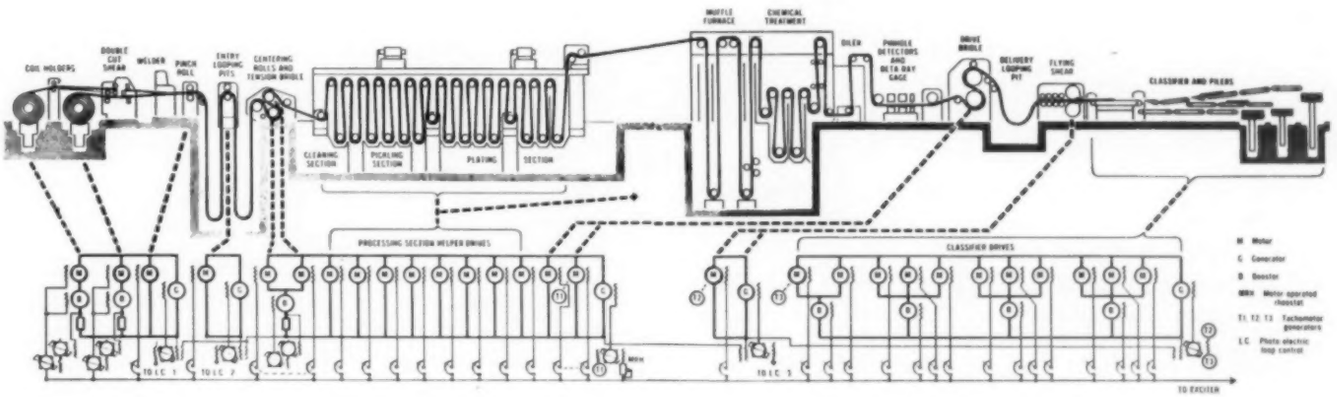


Figure 2 — Schematic diagram of a modern electrolytic tinning line in operation at Kaiser Steel's Fontana plant.

RECENT TYPICAL INSTALLATION

Representative of the many problems involved in electrical system engineering and their solution is the electrolytic tinning line shown diagrammatically in Figure 2. This line, recently installed at the Fontana, California plant of the Kaiser Steel Corp. is designed to operate up to 1250 fpm, and at the time it was installed was the fastest tinning line of the vertical acid type in existence.

Not only does this line represent a fair cross section of the varied problems of electrical system engineering, but the excellent operating results that have been obtained in the short time this line has been in service are a glowing tribute to the engineering contributions and outstanding spirit of cooperation of the electrical manufacturer, the machinery manufacturer, the installation contractor and the entire steel plant organization.

Entry end—The strip handling problems at the entry end of the line are essentially the same as those encountered on any continuous processing line. Two uncoilers, each with its own d-c drive motor, control and regulating equipment, are employed. The arrangement allows the operator to get ready a coil on the second uncoiler, for passage through the line, while strip is being unwound from the first uncoiler. Automatic control sequencing and interlocking is provided for the shearing and welding operations so that the time required to join the tail end of one coil to the front end of the next is held to a minimum.

The adjustable voltage system for the entry end is also designed to provide the optimum of performance—designed to reduce the downtime for the shearing and welding cycle to a minimum. A more detailed diagram of the entry end control system is shown in Figure 3.

The entry generator is under the control of a combination voltage and loop position regulator. During normal running conditions, one field of the rotating regulator measures the difference between the entry generator voltage and the main generator voltage and thereby sets the entry speed to approximately match the main line speed. Other fields of the rotating regulator are excited from the photoelectric loop control and act as vernier adjustments to hold the loop position at a point near the bottom of the first looping pit and thereby exactly synchronize entry end speed to line speed.

No programming control, such as a motor operated rheostat, is included in this system. The control of the rate of acceleration and deceleration is provided by the current limit feature of the regulating circuit. This current limit circuit combined with the inherent forcing characteristics of the basic regulating system allow the maximum rates of acceleration and deceleration to be employed consistent with the safe limits of machine commutation ability. The quick starting and stopping resulting from the system means that the entry end can be kept running longer before a stop, and be back up to speed quicker after a weld is completed than is possible with conventional programmed controls.

An additional step function reference signal is applied when the entry end is restarted. This function causes the entry end to accelerate to a speed 20 to 30 per cent faster than the center section and thereby restores the loop more quickly. Just before the loop reaches the modulating zone, a photoelectric relay operates to remove the step function, and the normal voltage reference signal plus the modulated loop control reference signal take over to bring the entry end to the proper synchronous speed.

Rotating tension regulators are supplied for each of the uncoilers. Due to the rapid rates of acceleration and deceleration provided by the entry generator control scheme, recalibration of the current feedback signal in order to compensate for the inertia of the uncoiler system is required. It is of interest to note that the determination of the size motor to be used on one of these uncoilers is predicated on the amount of torque required to accelerate the inertia of the reel and coil in the allowable time rather than the steady-state value of tension desired.

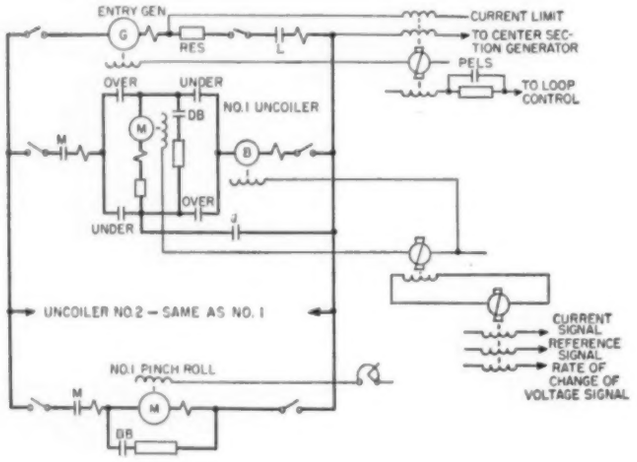


Figure 3 — Entry end control system for electrolytic tinning line.

The looping pit pinch roll is supplied from a separate generator and this generator is controlled in a manner the same as that of the entry generator. However, when the entry end is stopped, the speed of the pinch roll is regulated to a speed halfway between the entry end and the main line speed. In this manner, the two loops are paid out at an equal rate.

Additional photoelectric limit switches are provided to give indicating light indication as to the position of the strip in the pits and safety limits protect the equipment against faulty operation. Photoelectric limit switches located at the bottom of the pit operate to slow down the entry end should the amount of material in the pit become too great. Photoelectric limit switches at the top of the pit are set up to stop the line in case the entry end is not restarted before the material in the loops is almost depleted. Incidentally, these upper photoelectric limit switches are backed up by mechanical limit switches so that every reasonable precaution is taken to prevent the strip pulling completely out of the loops and tending to damage the walkways over the pits or the other mechanical equipment in the line.

Processing section—The strip propelling electrical system for the center or processing section of the line is shown diagrammatically in Figure 4. The main generator for this section of the line is under the control of a speed regulator. This regulator holds the speed of the line by comparing the output of a tachometer driven from the drive bridle to a potentiometer dial of the main motor operated rheostat. The operator preselects the operating position of the motor operated rheostat by means of the "high," "medium," and "low" preset rheostat dials located on the main control cabinet. The rate of acceleration and deceleration of the entire line is held, during normal operating conditions, to a relatively slow value by the speed of travel of the motor operated rheostat. Relatively slow speed changes, such as when the line is slowed down for a weld, are desirable in that the magnitude of transients introduced into the various regulating systems is held to a minimum and the quality of the tinplate produced thereby is more closely maintained.

When emergency stopping is required, however, a current limit stopping pumpback circuit is employed. The stored energy of the various drives are absorbed by the motor generator set at a rate consistent with machine commutating capabilities. It has been found from operating experience that the fast stop provided by the current limit control has definite operating advantages. When the line is emergency stopped as a result of strip breakage, the fast stop means that the distance the strip has to be jogged for rethreading is held to a minimum and that therefore the time lost before the line can be restarted after a break is greatly reduced.

In order to further reduce the rethreading time two progressive jogging controls are provided. One allows the strip to be threaded forward progressively from the drag bridle, and the other allows the strip to be threaded in the reverse direction progressively from the master pulling bridle.

The drag bridle is controlled by a current regulator so as to hold a constant tension in the strip through the processing section. The maintenance of tension in this

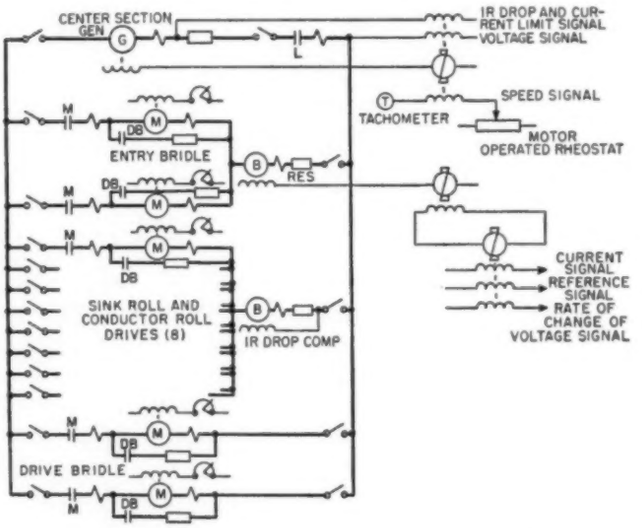


Figure 4 — Center section control system for electrolytic tinning line.

section is most important due to the higher current densities that must be conducted from the various conductor rolls to the strip. Any loss of tension in this section while current is being conducted in the various electrolytic processes would result in arcing between the strip and the conductor rolls with resultant strip burning.

Tension regulation of the drag bridle (with suitable inertia compensation) is maintained even during the current limit stopping and all of the drives are brought down together. However, when the line is stopped the

tension is removed so that the operator is required to reestablish this tension before the line can be restarted.

Quick stopping by dynamic braking is also provided. It is brought into play when any of the machine protective devices operate due to overcurrent or loss of motor field. When one of these protective devices operate all of the drives are disconnected from the generator and dynamic braking applied individually.

Cleaning and pickling—Two cleaning generators, are used in the electrolytic cleaning section. The control of

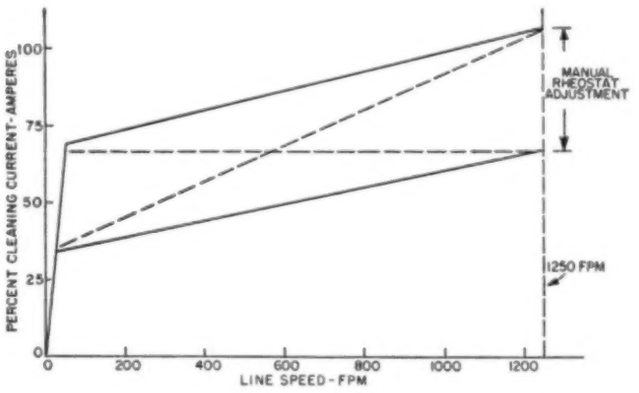


Figure 5 — The relation of cleaning current to line speed on an electrolytic tinning line is given by the chart.

these generators is arranged to provide overcurrent and undercurrent protection, manual or automatic polarity reversal, generator field suiciding on removal of excitation, and control of electrolytic current as a function of line speed. The automatic polarity reversal operates from the uncoiler selector switch at the entry end of the line and it is arranged so that in effect strip from the No. 1 uncoiler is subjected to cathodic cleaning and a strip from the No. 2 uncoiler is subjected to anodic cleaning.

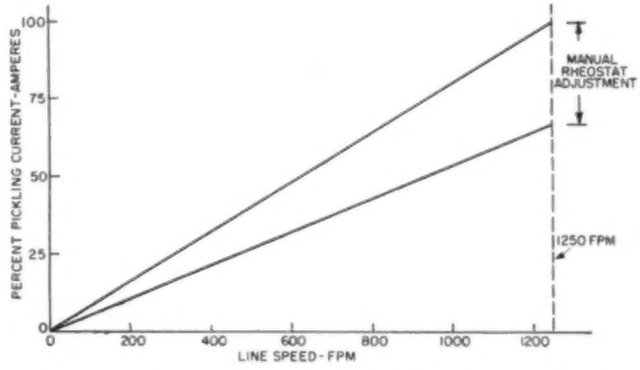


Figure 6 — The relation of anodic pickling current to line speed on an electrolytic tinning line is given by the chart.

The adjustment of cleaning current as a function of line speed is provided by a dial section of the main motor operated rheostat. This rheostat dial together with a hand operated rheostat provides for a flexible cleaning current versus line speed relationship as shown in Figure 5. In order to prevent any electrolytic current flowing when the line is stopped, excitation is not applied to the cleaning generators until the line starts. The generator field circuits are suicided in order to reduce residual voltage to prevent circulating current through the bath when the line is stopped.

Four pickling generators are employed, and control of these generators essentially the same as that employed for the cleaning generators with the following exceptions:

1. Polarity reversal—manually only.
2. Although the same relationship between current and speed as shown on the previous figure may be maintained for cathodic pickling, on anodic pickling a relationship as shown in Figure 6 may be provided.

Plating—Twelve plating generators are employed, with a total plating capacity of 90,000 amperes. The control of each generator provides overcurrent and undercurrent protection and a suicide circuit for killing residual voltage when excitation on the generator is removed. A plating current regulating system controls the excitation to all generators to maintain accurately the relationship of total plating current to line speed. This system is shown schematically in Figure 7.

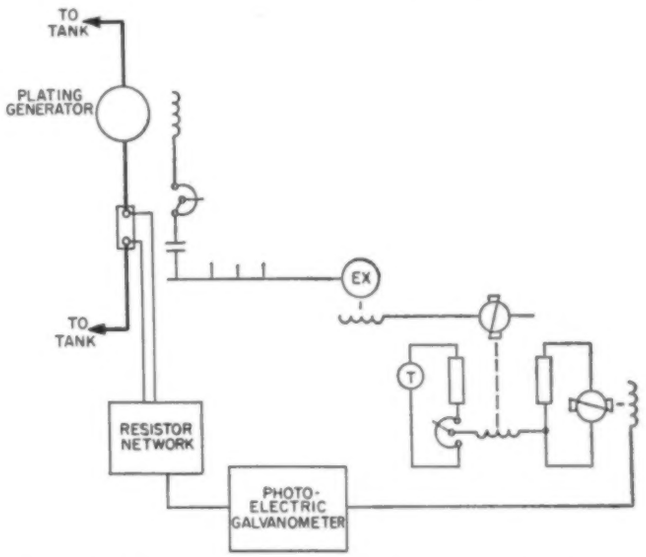


Figure 7 — Plating current regulating system for electrolytic tinning line.

A resistor network totalizes the individual circuit currents by measuring the drop across the 50 millivolt shunts. This totalized signal is fed into a photoelectric galvanometer and the current signal rotates the galvanometer element to which a mirror is attached. This movement of the mirror upsets the signal from the double element phototube. The error signal from the phototube is amplified and fed into a rotating regulator. The output voltage of the regulator is connected to a second coil of the galvanometer to bring the mirror back to the correct neutral position and the rotating regulator output is also fed into the plating current regulator. The system is quite accurate and fast in response. The system performs successfully even though the number of generators in use is varied from time to time. A picture of the galvanometer is shown in Figure 8.

Due to the limited storage capacity in the looping pits, the line is designed to slow down from high speed

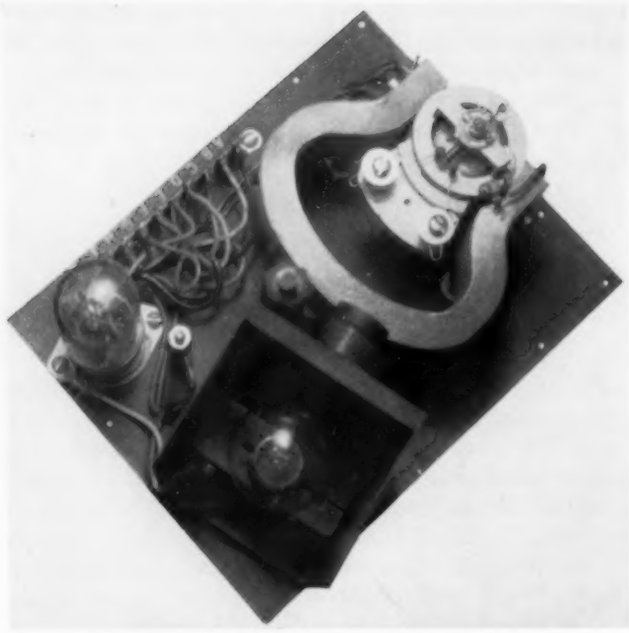


Figure 8 — Photoelectric galvanometer is used in plating current regulating system of an electrolytic tinning line.

to some intermediate speed whenever a weld is to be made. Limit switches are provided on the main motor operated rheostat and the operation of these limit switches is used to vary the number of generators employed in the plating circuit for different line speeds. It is interesting to note that the current totalizing system gives an accurate measure of total amperes regardless of the number of generators employed.

The system employed is also well adapted to differential coating. Although the use of two independent regulating systems would make the setup for differential coating somewhat simpler for the operator, the system as employed on this line operates satisfactorily for differential coating production as long as the proper deselection of generators is made.

Flow brightening—The electrolytic tin coating as it is emerged from the plating tanks has a dull crystalline finish and must be "reflowed" or "flow brightened." The flow brightening is accomplished in the muffle furnace by means of electric conduction heating supplied to the conductor rolls at each end of the furnace from two single phase transformers.

The control of this power is accomplished through a saturable core reactor connected in series with the primaries of the two load transformers. The d-c excitation of the reactor (therefore the throttling effect on the load transformers) is controlled by a rotating regulator that regulates the output voltage of the load transformers approximately proportional to the square root of line speed.

Since the kilowatt output of the load transformers is proportional to the square of the applied voltage, the regulator, by holding output voltage equal to the square foot of line speed, holds the kilowatt output directly proportional to line speed and therefore the watts per linear foot of strip is held at a constant. The Btu's per linear foot or therefore the amount of heat put into the strip is held at a constant value. The relative level of this constant heat input value is adjusted manually by the operator to a point where he visually observes the proper conditions of the flow brightened strip as it emerges from the muffle furnace.

At the time this method of flow brightening was first developed special saturable reactors were difficult to obtain due to the shortage of engineering personnel and manufacturing facilities during World War II. Fortunately men of vision in our major steel plants were able to apply to this application normal single phase transformer designs in place of the saturable reactor with excellent results. Two transformers, with their secondaries connected in series such that the impressed a-c voltages cancelled one another, were used in place of the reactor. D-c excitation was supplied to this secondary connection and the normal transformer designs were used as saturable reactors.

A value of 2300 volts was the secondary voltage rating selected for these transformers used as reactors. The selection of this voltage proved quite satisfactory on the original installations. It was felt that with the use of 2300-volt secondaries the problems of adequate equipment and personnel protection due to the impressed a-c voltage could be adequately taken care of. The original units were rated about 500 kva each so that the d-c excitation required a fairly normal exciter design.

As the speed of these lines has been increased over

Figure 9 — Load transformers and saturable reactor were used for "flow brightening."

Figure 10 — Only part of the electrical basement of an electrolytic tinning line is shown in this view.

the years, the size of the transformers has increased accordingly. The present requirement of two large transformers with 2300-volt secondaries requires an exciter rated somewhere in the neighborhood of 20 kw and 25 volts. Such an exciter is of course of special design, and a 25-volt machine also becomes a difficult machine to suicide, and the killing of residual voltage in the exciter circuit is very important.

From the standpoint of first cost, preliminary studies show that the saturable reactor such as employed on this line, has a cost comparable to that of two equivalent normal transformers. It is therefore felt that the use of the reactor, while not requiring any additional first cost, reduces the safety hazard of the induced a-c voltage as well as making possible the use of a more conventional exciter design and greater ease in killing residual voltage on the exciter. An installation photograph of reactor-transformer combination used on the Kaiser tinning line is shown in Figure 9.

speed of the strip coming out of the shear even though there is a wide difference in the relative inertias of the belts compared to the shear.

Individual boosters are supplied for each flight of the classifier. In the event of cobbles on any one flight, that flight can be shut down, the cobble cleared, and the flight reaccelerated to operating speed without affecting the operating of the other flights. The boosters also provide means for independent jogging of each flight in either direction to further assist in the clearing up of cobbles.

Basement layout—Further concept of the size and complexity of the system engineering job on this particular tinning line is shown in the photograph of the electrical basement (Figure 10). In this photograph on the left is seen the lineup of d-c control, including the control for the various low voltage generators for pickling, cleaning, plating and chemical treatment, plus the adjustable voltage control for the strip propelling

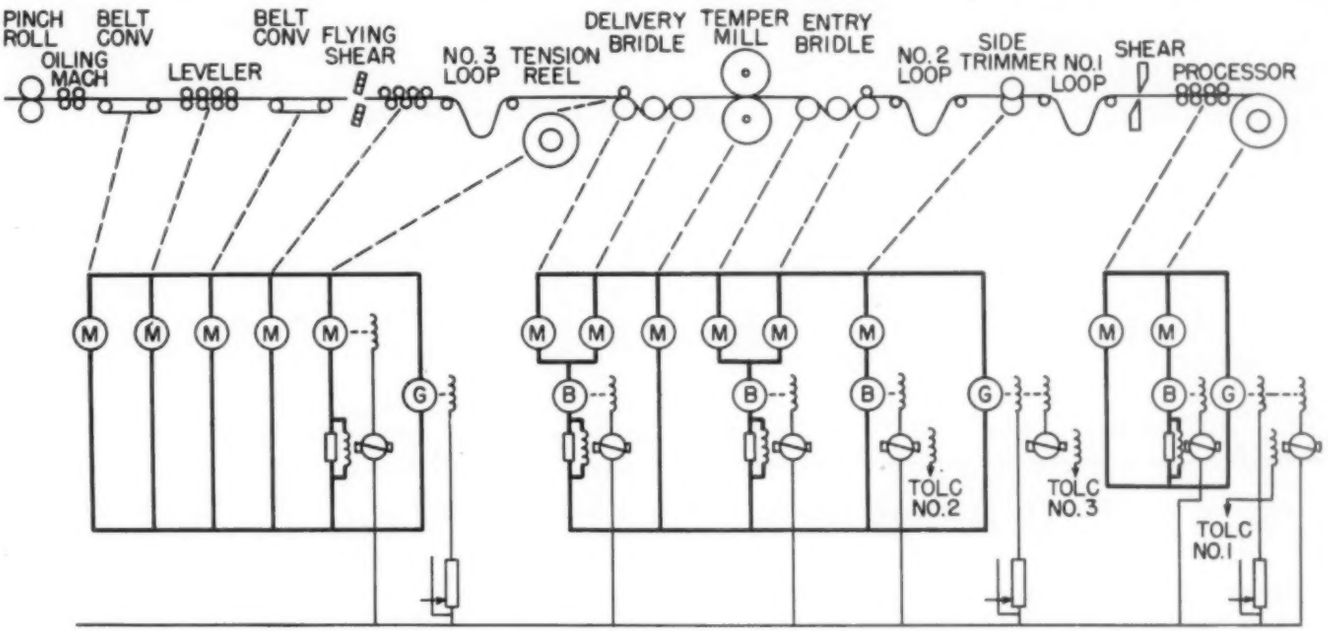


Figure 11 — Simplified schematic diagram of a combination shear line-temper mill.

Flying shear—The flying shear in the delivery end of the line is supplied with power from a separate generator. This generator is under the control of a rotating voltage regulator with a loop control vernier. Current limit control on acceleration and deceleration is also employed and IR drop compensation is included so that the electrical system can adequately compensate for the high inertia characteristics of the flying shear drive.

Classifier drives — The maintenance of proper gap between sheets on the inspection conveyor and the maintenance of proper shingling on the piling conveyors of a tinplate classifier is a problem of long standing. On this particular line a step toward the solution of this problem has been made by supplying the classifier motors from a separate generator, and by means of a speed regulator matching the speed of the No. 1 inspection conveyor to the speed of the shear leveling rolls. With this speed tie, the speed of the classifier belts is more accurately held in synchronism with the equipment. This control panel is approximately 100 ft long. To the right and in the background can be seen a number of the exciters and regulators. In the far background is located one of the two a-c motor control centers which provide control for the numerous a-c motors and solenoid valves associated with the line equipment. At the extreme far end of the basement are the discharge ducts from the blower fans that supply cleaned, cool air to the entire basement area. Also located in the electrical basement are the various low voltage motor-generator sets, the transformers and reactors for the flow brightening circuit and 2300-volt starting equipment for the various low voltage motor-generator sets.

SUMMARY

It has not been the author's intent to discuss all of the electrical problems involved in this particular in-

stallation but rather to point out some of the outstanding features of this line to exemplify the problems of electrical system engineering on any continuous strip processing line. Many other special electrical tools are employed. Pinhole detectors are used. A beta-ray thickness gage is employed in checking the thickness of the coated strip. A magnetic amplifier is used in regulating the flow of current in the chemical treatment section of the line. Electronic sheet counters are employed, and so on.

Other types of continuous processing lines use many of the same tools employed on this line but most likely in different combinations. Other specialized tools are employed. But in each case the system engineering approach is required to properly evaluate and coordinate all of the various items of equipment involved. Adequate attention has to be given to the power distribution system. The proper arrangement of power circuits must be determined with adequate attention given to problems of interrupting capacity, voltage fluctuations and continuity of service.

Recent years have seen a rapid advance in the art of strip steel processing. Steps have already been made in the direction of combining rolling and processing operations into one continuous process. The combination temper rolling and shearing line such as shown schematically in Figure 11 is an excellent example of the steps that have been taken in this direction.

The electrical industry stands prepared to further this progress and with the cooperation of the machinery manufacturer, the steel plant engineer and the installation engineer, we hope to see the day that the entire cold mill process all the way from the pickle line to the tinplate pilers will become one continuous operation.

DISCUSSION

PRESENTED BY

FRANK C. FENNELL, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

R. T. LUCAS, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

E. E. VONADA, Application Engineer, Reliance Electric and Engineering Co., Cleveland, Ohio.

A. R. GEISZLER, Application Engineer, Wean Engineering Co., Inc., Warren, Ohio.

R. J. BEESWY, Superintendent Electrical Dept., Inland Steel Co., East Chicago, Ind.

J. S. APPERSON, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

F. C. Fennell: I am certain that Mr. Apperson does not wish to leave the impression that the system engineering approach to processing lines has been missing all these past years. Also, I feel sure he does not intend to imply that electrical manufacturers are just beginning to realize the benefits that can be gained by the application of system engineering thinking to the design of today's more complicated lines. The reason I emphasize this point is that the system engineering approach, while not necessarily so named, was certainly

Figure 12 — Electrolytic tinning line shown is located at Weirton Steel Co.'s plant at Weirton, W. Va.

evident when the forerunners of present day electrolytic tinning lines were designed and installed in the late 1930's and early 1940's.

These lines were a radical innovation in the processing line field as it was then known. The early horizontal type tinning lines were designed to operate at 1200 fpm, a speed nearly equal to the fastest lines of any type then in operation. The designers of these lines encountered and were forced to solve the special problems always inherent in such high speed operation. Practical and economical solutions to the problems of accurate plating power control and flow brightening processes were found only after thorough analyses and tests of a number of different possible methods. The early solutions to these knotty problems have proven to be so sound in the light of system engineering that present day lines such as those shown in Figure 12 still incorporate these same basic approaches to the overall system design.

These modern lines have of course made progress—operating speeds have nearly doubled as shown in Figure 13. Such lines have operated successfully at speeds as high as 2200 fpm. This increase in speed has brought increased complexity to the electrical system so that today such lines require power equivalent to the combined output of 36 large radio stations just for the reflow or flow brightening process. Over 3000 kw in low voltage d-c power is now required for the plating, cleaning, and chemical treatment processes, and the number of drives has grown so far that today a single line will use 225 motors totalling over 2700 hp. As Mr. Apperson has already stated, such lines certainly are no mere collection of pieces. The co-operative efforts of engineers from the steel plant, the machinery manufacturer, the construction contractor, and the electrical manufacturer have been brought into focus to make such complex lines possible.

R. T. Lucas: Your Figure 12 is a little reminiscent of the place where I probably should be today. That was our electrolytic line at Weirton. I do not know whether Mr. Fennell included our recent changes, but on our reflow we are adding an additional 600 kw of capacity, so that while we had 1800 kw to start with, we will now

end up with 2400 kw of reflow power.

E. E. Vonada: We have been associated with the electrical drive equipment for the U. S. Steel Corp. type of tinning lines since their inception back in 1941. At that time the motor drive system was set up on the basis of a 3:1 constant horsepower range to cover a major part of the normal operating speed range. This was done to assure adequate break away torque to start the strip moving through the line.

After the first few lines were put into operation, experience dictated that the motor constant horsepower range was not necessary, and the drive arrangement was changed to one using constant torque motors which is the drive system shown and described by Mr. Apperson.

To obtain the operating results in the short time indicated in the paper, it is not only necessary to apply the system engineering principles to the electrical system, but to the entire processing line installation. In general, this embodies the careful determination of the correct design for the individual machines which perform the various operations involved in the process, and the proper coordination of these machines into a completely integrated processing line. The selection of this equipment must be continually tempered by maintenance and economic considerations, and the preferences of the industry personnel. Consequently for a line of the type described, it becomes essential that attention be given every detail to attain the perfection expected of modern processing lines. The majority of such details are usually resolved through the

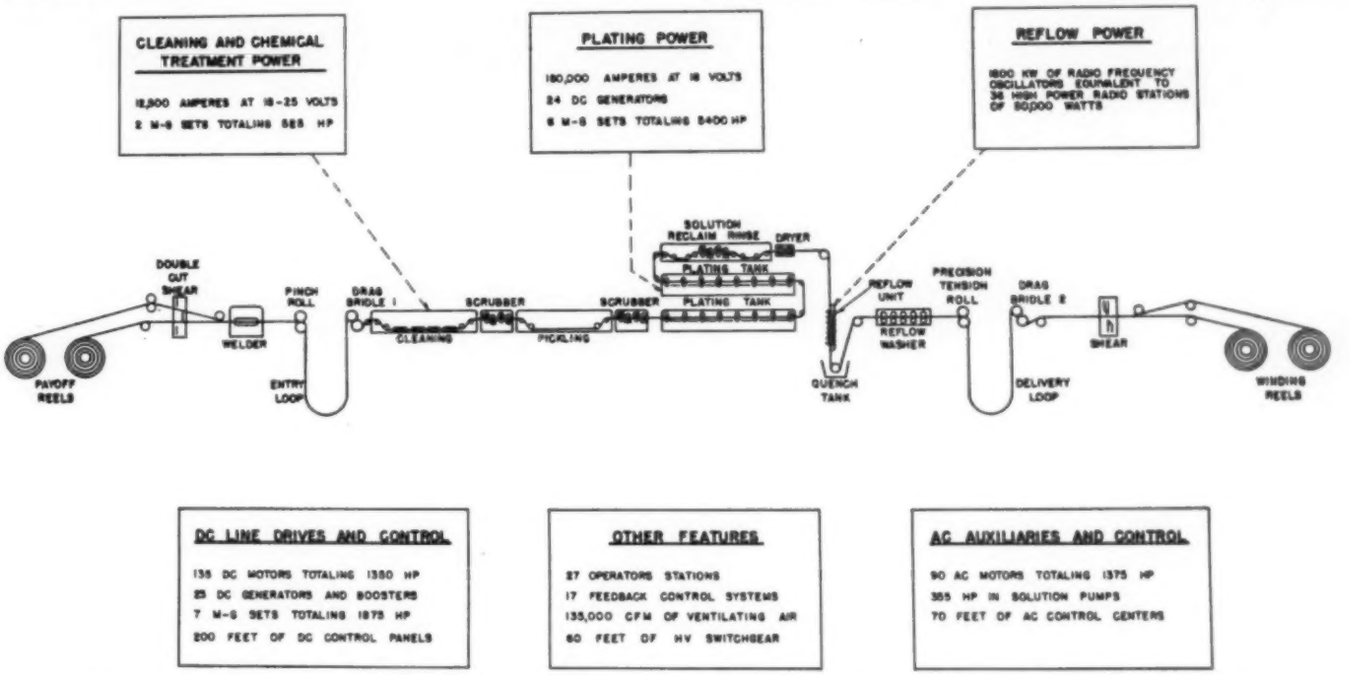


Figure 13 — Horizontal acid type electrolytic tinning line has line speeds of 2000 fpm and up and total power requirements of about 10,000 kva. Production is about 250,000 tons per year.

Over the years we have seen a progressive increase in maximum operating line speed, with resultant increase in processing tanks. As a result, strip tension at the main pulling bridle became excessive, necessitating the addition of helper drive motors for conductor and sink rolls. Mr. Apperson's figures show the present drive system for these helpers.

I have one question I would like to ask Mr. Apperson: That is, how does he provide for the load balance between the bridle motors? Normally, the bridle motors are of dissimilar horsepower, and it seems to me there should be some system to provide for load sharing.

A. R. Geiszler: Mr. Apperson has done a commendable job of outlining the necessity of system engineering of the electrical system for a line such as the Kaiser tinning line. This electrolytic tinning line was installed by Kaiser Steel under license from the U. S. Steel Corp. and designed and built by our company. Mr. Apperson has discussed the tinning line so completely that no further comment is required. Of course, what he has said about system engineering for the tinning line applies to a lesser or equal degree to any processing line. combined cooperative effort of everyone involved in the project. The postwar trend of the majority of the steel plants has been to assign full line responsibility to the machinery manufacturer in order to furnish direction and purpose to the effort involved. To us it has, indeed, been an inspiration to participate in the genuine cooperation displayed by all phases of the steel plant operation involving every man contributing to the project.

The necessity for this system engineering has come about for two reasons: one, because of labor conditions, processes must be combined to obtain a more efficient overall operation; and two, because there have been, are, and always will be men of vision and courage in the industry. Figure 11 of the combination shear and temper mill line, indeed, is a testimonial to the vision and faith of such men. Two of these lines are now in operation and giving excellent accounts of themselves.

With the vision and courage displayed by the men in the steel industry and the continued cooperative effort between them and the machinery and electrical manufacturer, perhaps Mr. Apperson's crystal ball

processing line, beginning with the pickling line and ending in the tinplate piler, is not in the too distant future.

R. J. Beeswy: We in maintenance become alarmed by the picture of the line control basement with its many control boards and further so at hearing Mr. Apperson talk of 20 feed back control units.

What is being done to simplify maintenance?

Inland has caustic lines and one of our problems is strip tracking. Is this likewise true of line referred to in Mr. Apperson's paper?

We have experienced some trouble and expense with our plating current collector system. Loop control is another problem. In the paper, photo electric cells control the total plating current. What has been the experience with tube failures?

J. S. Apperson: First may I answer Mr. Vonada's specific question concerning load balance between motors of multiple drive bridles. We have not found it necessary on a line of this type to employ any special regulating means to provide adequate load balance between motors on such a drive. The inherent drooping characteristics of the motor, plus perhaps external drooping resisters, have given sufficient droop to the motor speed characteristics so that two dissimilar rated motors on the bridle can operate together satisfactorily. There is a case however, where additional means of insuring load balance is necessary. Such a case is where the motors may be operating as motors one minute and as generators the next. Under such conditions, the drooping characteristics of the machines operating as motors result in rising speed characteristics when operating as generators, and the machines will no longer carry their proportional share of the load. This condition can be compensated for with some rather straightforward control schemes but not necessarily involving regulating equipment.

Mr. Beeswy certainly reflects a natural reaction of maintenance and operating people. However, the amount of electrical equipment involved on a continuous processing line should be no more alarming than the amount present on a modern hot strip mill. The important point to consider is that although there is an unusually large collection of electrical equipment, this equipment breaks itself down into a collection of relatively easily understood fundamental pieces, with those pieces tied together to make an overall system. Twenty regulating systems does sound like quite a large number but when considered one at a time each system is no worse than any other one regulating system.

I am unable to speak authoritatively on how to control or eliminate tracking problems. Although we in the electrical industry are constantly attempting to assist in the solution of these problems, the basic difficulty is mechanical and not electrical.

The loop controls are a source of maintenance. Any tube has a limited life. It is rather interesting to note, however, that although the first modulated loop controls were of the photo-thyratron type (which meant they involved gas filled tubes) on the Kaiser tinning line and similar applications, we have eliminated the gas filled tubes from the circuits. We take the output signal of the phototubes, amplify the signal through hard tube amplifiers, and apply the output of the hard tube amplifiers to the rotating regulator control circuits. The elimination of the gas filled tube with their limited life characteristics, and the use of only hard tubes which have good life characteristics has reduced the maintenance problem on loop controls.

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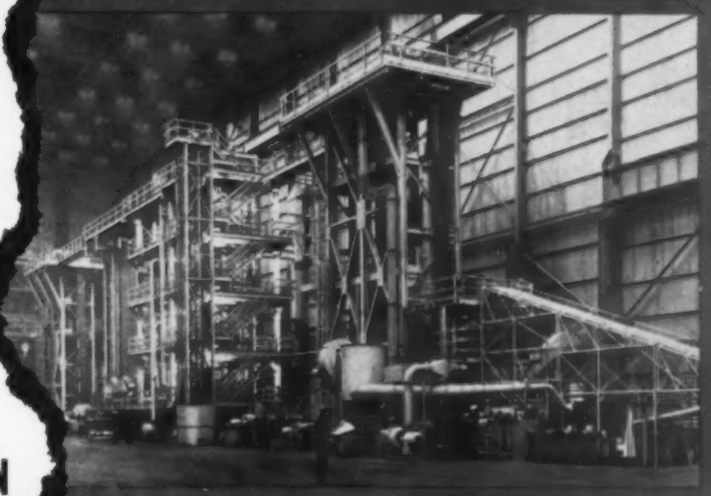

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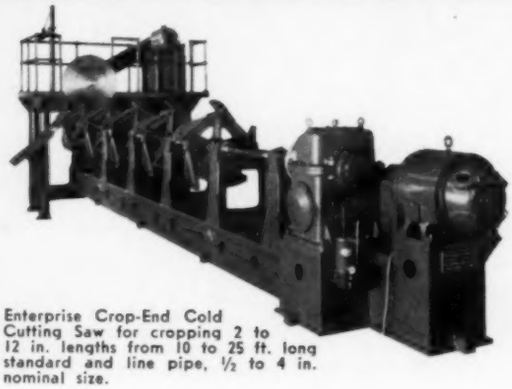
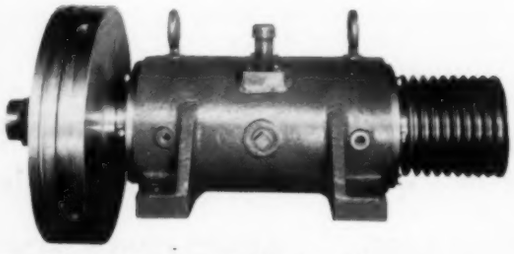
In Operation at NATIONAL TUBE DIVISION UNITED STATES STEEL COMPANY FAIRLESS HILLS, PENNA.



Enterprise Crop-End Cold Cutting Saw for cropping 2 to 12 in. lengths from 10 to 25 ft. long standard and line pipe, ½ to 4 in. nominal size.



The Enterprise Friction Saw Spindle Assembly is the heart of the machine. Saw arbor is of forged steel held in special self-aligning spherical roller bearings. Assembly is dynamically balanced for 22,000 fpm sawing speed with 42 in. steel saw.

Shown here is an Enterprise Middle-cut Cold Cutting Saw, complete with five-station turret feeding mechanism, for production cutting ½ thru 4 in. (4.500 in. OD) standard pipe in standard and extra strong weights in lengths ranging from 18 to 25 ft.

ENTERPRISE Friction Saws employ the heat of friction to cut hot or cold steel sections faster than any other known method of sawing. The fast-spinning steel blade, having a large peripheral surface in comparison with the contact area, generates localized heat in the piece being cut. The resulting highly localized temperature is sufficient to weaken the contact surface allowing the saw to wipe it away without noticeably heating the blade or the remaining section. The chips removed are in the form of minute oxidized flakes thereby indicating that friction sawing is indeed a true method for sawing metals. An increasing number of applications indicate a general trend towards friction sawing in industry today.

The Enterprise Company designs and builds special friction sawing machines complete with synchronized handling tables and conveyor systems to suit particular requirements . . . If your company has a production cutting-off problem, consider friction sawing as a possibility. The Enterprise Company will gladly serve as your source for the equipment required.

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(PHOTO COURTESY OF U. S. STEEL CORP.)

Drawing an ingot from one of the twenty soaking pits designed and constructed by Loftus at United States Steel Corporation's new Fairless Works.

- **Cycle timer for accelerating initial temperature head.**
- **Recirculation through normal combustion system to speed and unify heating.**
- **New Low-Stress . . . Hi-Heat 1500°F (Plus) Recuperator of Proven Construction and Materials.**
- **Completely Automatic Dual Combustion System... Dual Heat Distributing Outlets.**
- **INTEGRATED . . . ABSOLUTELY FOOL-PROOF RECUPERATION.**
- **THE PIT WITH THE THERMAL FLYWHEEL.**

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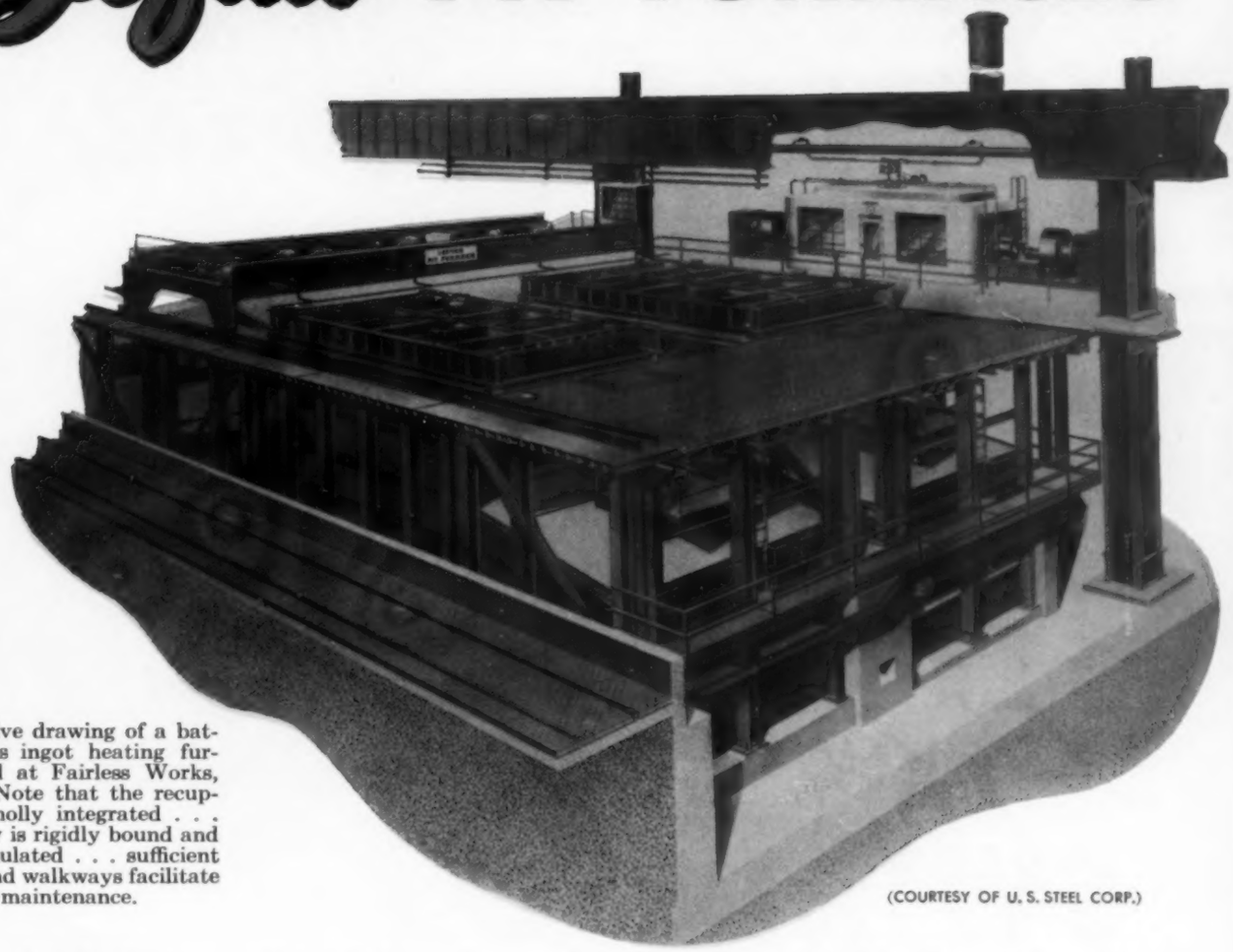

True perspective drawing of a battery of Loftus ingot heating furnaces installed at Fairless Works, U.S.S. Corp. Note that the recuperators are wholly integrated . . . entire pit body is rigidly bound and completely insulated . . . sufficient access stairs and walkways facilitate operation and maintenance.

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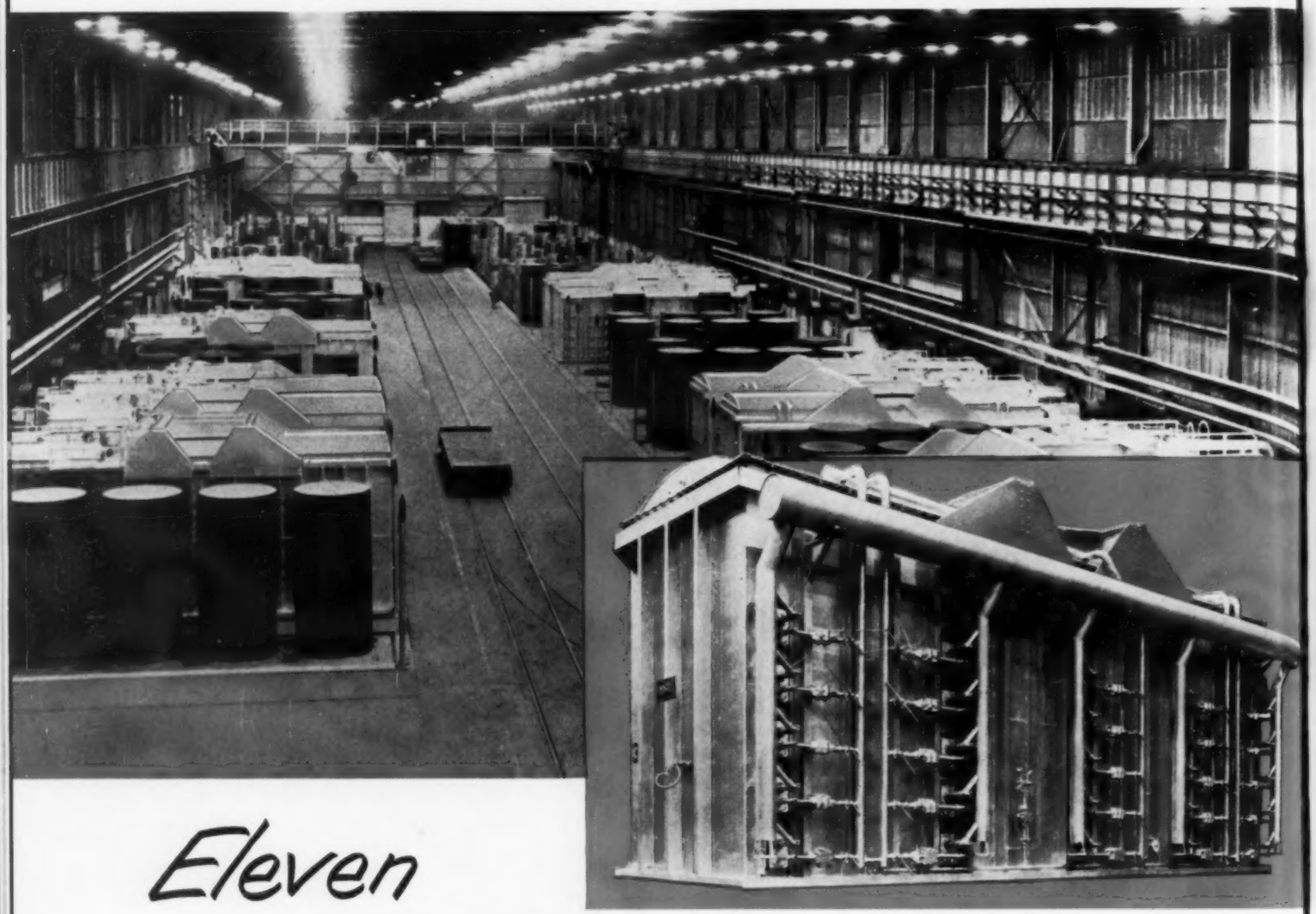
For the *Fairless Works* of UNITED STATES STEEL—



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PLUS 27 BASES

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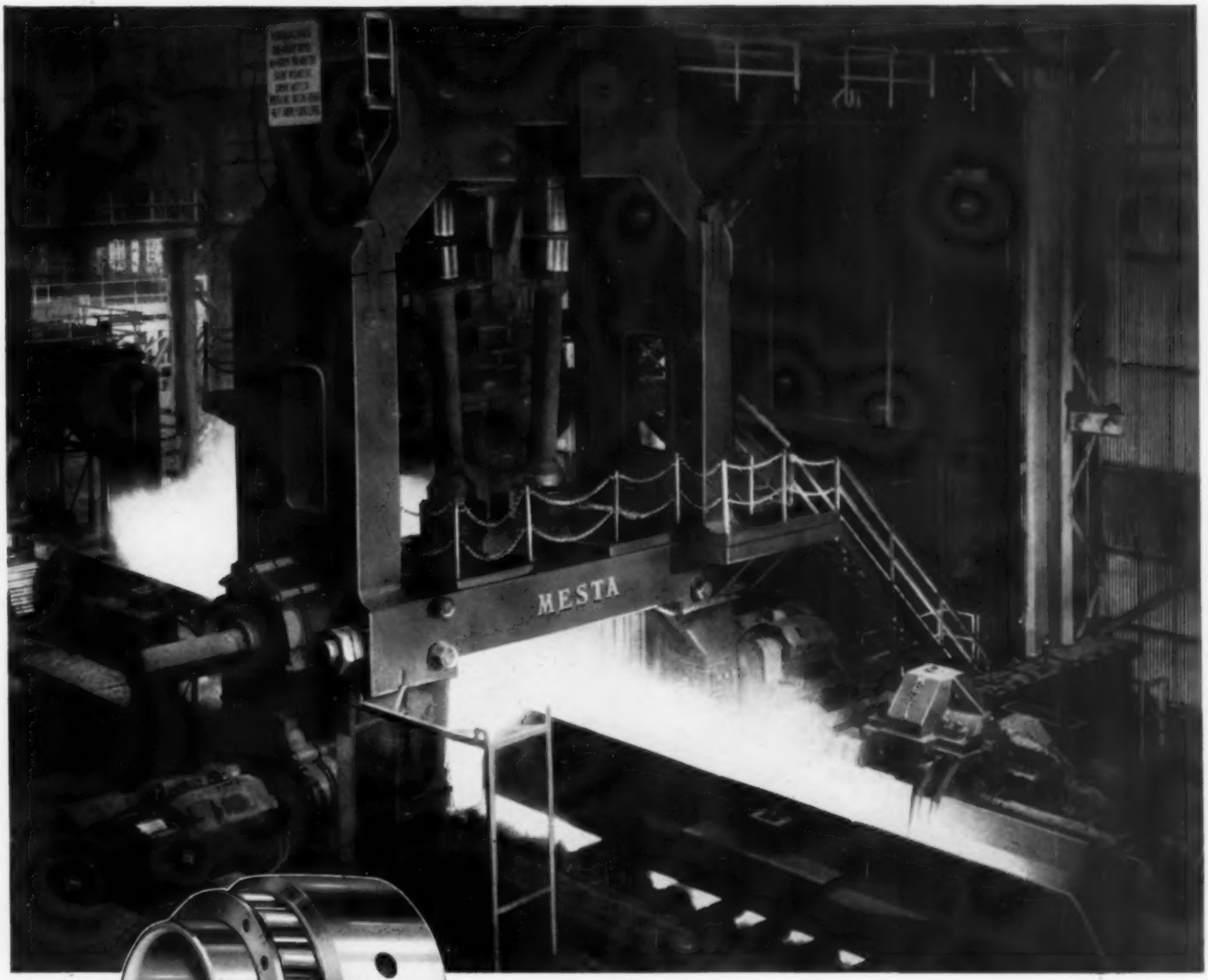

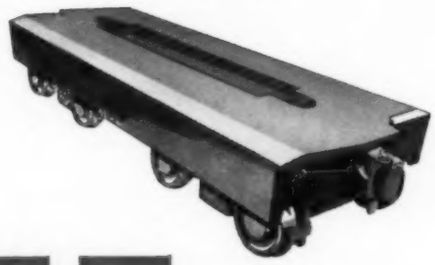

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From the start, I-T-E gave important engineering assistance in the preparation of specifications and in expediting *switchgear* orders for the Fairless Works. As a result of this close cooperation, power distribution equipment was on the ground *when needed* to fit right in with tight construction schedules.

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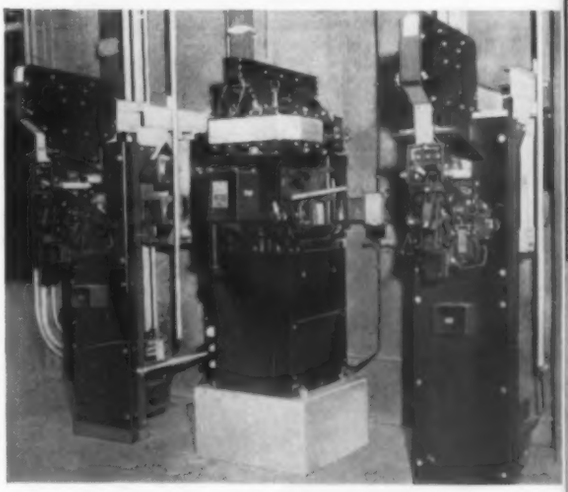

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Types MT and OH, used for DC sectionalizing in billet mill.

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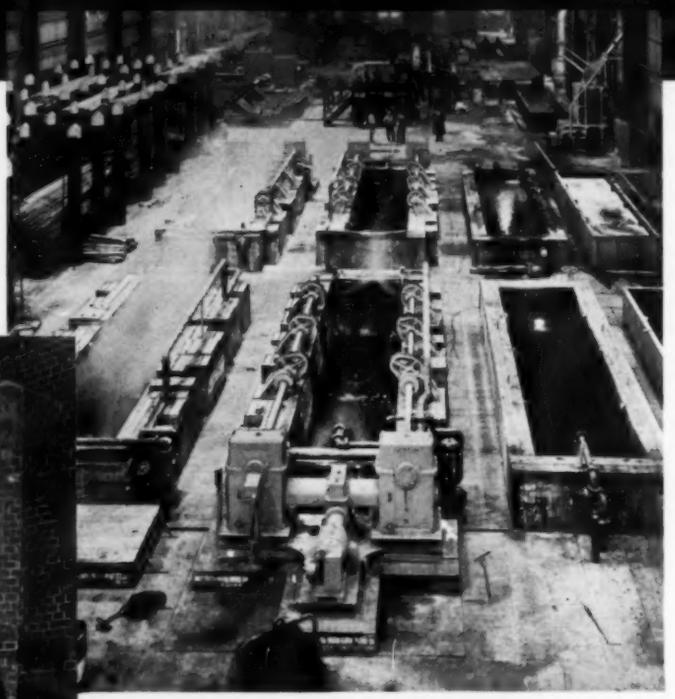
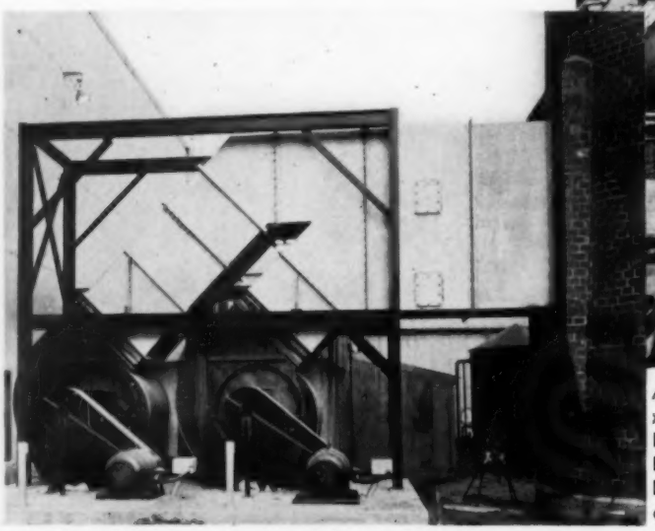


At right—Six tube pickling tanks of reinforced concrete, lined with (a) KEMSEAL membrane and acid-proof brick joined with (b) LECITE. Each tank is 30′ x 7′ x 6′. These tanks handle hydrochloric and sulphuric acids at high temperatures.



At left—Fumes are drawn into underground duct 170′ long x 12′ wide x 8′ deep, lined with KEMSEAL membrane and LECITE-joined acid-proof brick. Fumes pass thence into (c) DUROPRENE-lined steel above-ground ducts, through large DUROPRENE-lined fume scrubber and finally into 75′ stack constructed of acid-proof brick joined with (d) BRIMSTO.

The above installation was made by Electro Chemical Engineering & Manufacturing Co., in the new Fairless Works, National Tube, United States Steel Corporation, at Fairless Hills, Pennsylvania.

This Fairless Works National Tube installation, including all acid-proof materials, is EL CHEM throughout.

(a) KEMSEAL—*⅛″ thick plastic impervious membrane, reinforced with glass cloth*
(b) LECITE—*Furan acid- and alkali-proof resin cement*
(c) DUROPRENE—*Neoprene rubber lining*
(d) BRIMSTO—*Plasticized sulphur-base cement*

We are equipped to furnish complete acid-proofing service to meet any condition and any type of industrial corrosive.

The experience and advice of our engineers is at your command without obligation.

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Congratulations

Joe Magarac never dreamed of a steel plant like the new U. S. Steel Fairless Works. It is the largest single steel plant ever built at one time. The William B. Pollock Company is pleased to congratulate U. S. Steel on the completion of this mammoth project.

In conjunction with Arthur G. McKee and Company of Cleveland, Pollock fabricated the steel for both of the Fairless blast furnaces and furnished much of the allied operating equipment.

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HOW LINK-BELT

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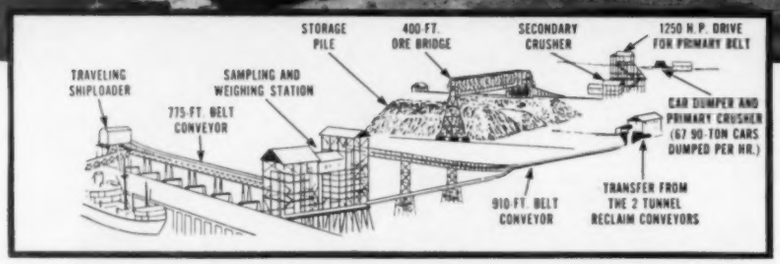
largest iron ore handling system ever built at one time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TRAVELING SHIPLOADER
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Aerial photograph and schematic flow sheet trace ore's movement from railhead to ship. Link-Belt belt conveyors along dock and boom load a ship. The facility may be expanded, when necessary, to load ships at 12,000 long tons per hour.

LINK-BELT fulfills "turn-key" responsibility for design, fabrication and erection of 6000-ton-per-hour ore-handling system in Venezuela

TO MOVE Cerro Bolivar's ore from mine car terminal to ocean-going ships, U. S. Steel's Orinoco Mining Co. appointed Link-Belt the prime contractor. The project was engineered, fabricated and installed in 23 months —five months ahead of schedule. This was accomplished with the excellent cooperation of suppliers and our subcontractors, Wellmann Engineering Co. and McDowell S. A. of Caracas.

As the ore moves via Link-Belt belt conveyors to the ships, it is crushed in two stages. Enroute it is also stockpiled to be reclaimed as needed at a rate of up to 6000 long tons per hour. The shiploader is versatile enough to handle all types of ocean-going ships plus a 39-ft. annual water level variation of the Orinoco River. One shiploader operator electrically controls the speed and capacity of the entire reclaiming system—from storage pile to the ship.

On projects large and small, Link-Belt offers unified responsibility for materials handling and processing plants —from design to successful operation. A call to your nearby Link-Belt office will place the facilities of this comprehensive organization at your service.

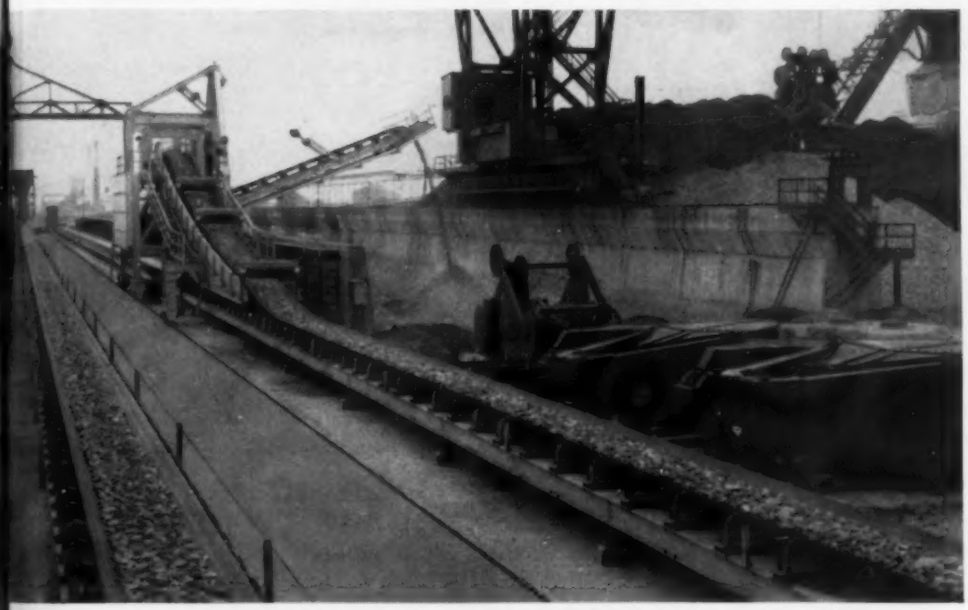
LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

13.517

SERVES U.S. STEEL-

2 AT FAIRLESS WORKS

largest integrated steel mill ever built at one time



ORE from ship unloading tower is delivered to conveyor on left from which it is transferred to the conveyor on the right. Then the travelling stacker discharges into the trough from where it is re-cast into the storage yard by the bridge.

COAL whether water borne or from railroad cars is moved to storage or directly to the coke plant on this conveyor which is equipped with Link-Belt idlers.

COKE travels from the coke plant to the blast furnace stock bins via this 5611-ft. long belt conveyor.

LINK-BELT equipment forms integral part of Steel's "dream" mill

WHEN U. S. Steel planned the new Fairless Works, they were not hampered by any of the usual restrictions, such as space and existing equipment. They could—and did—design a "dream set-up." And they called on Link-Belt to supply vital parts of the big, flexible conveying systems in various areas of the mill.

Raw materials—ore from ship unloaders, coal from ships or railroad cars and coke from coke plant to stock bins—are all handled by belt conveyors equipped with Link-Belt heavy-duty idlers and speed reducers. Also, following modern coke plant practice, all ammonium sulphate is dried in a Link-Belt Roto-Louvre Dryer.

The complete coil conveyor system for the hot strip mill was designed by Link-Belt, who also designed and furnished the rugged booster drives for this system. P.I.V. speed changers were selected for the exacting requirements of the flying shears in the tin mill—and Link-Belt enclosed gear drives are used extensively in other sections of the mill.

The Fairless Works also uses Link-Belt conveyor chains and sprockets, bearings, a trolley conveyor and other essential equipment.

For complete information on equipment Link-Belt builds to handle bulk materials and steel in every form—call your nearest Link-Belt district office. Our engineers will work with your engineers, consultants and builders of mill and process equipment—help you achieve modern efficiency in your mill.

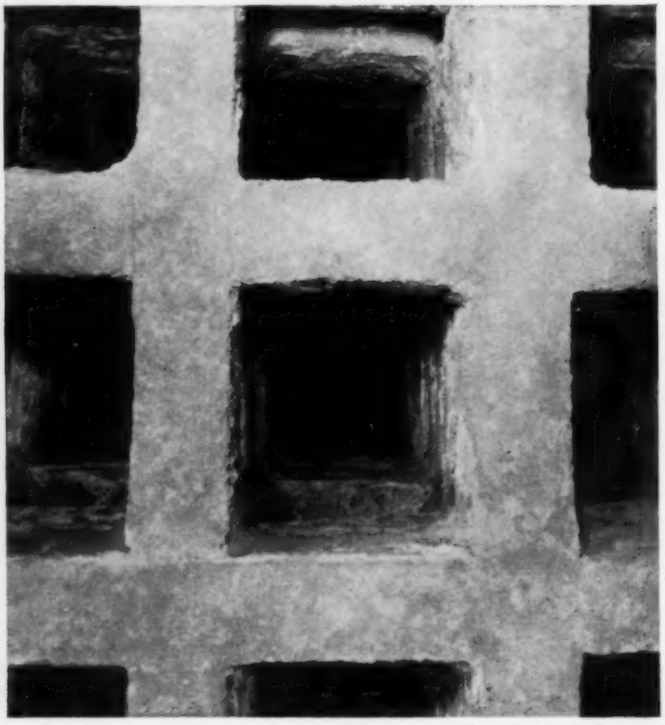
LINK-BELT

One source . . . one responsibility for materials handling, processing and power transmission machinery

FOUR OPEN HEARTH CHECKER CHAMBERS CLEANED IN 10½ HOURS

Expensive rebricking job avoided; deposits removed from checkerworks by DOWELL engineers using a high-pressure solvent jet

Before chemical cleaning



After chemical cleaning

Recently, Dowell was called to clean four badly fouled checkerwork chambers of an open hearth furnace. A high-pressure solvent jet, designed by Dowell to combine chemical and hydraulic action, made it possible to complete the job in only 10½ hours!

Inspection after cleaning showed the checkerworks to be free of deposits. This cleaning by Dowell Service avoided an expensive rebricking of the checker chambers which would have required a maintenance shut-down of four or five weeks.

This was the fourth time these checkerwork chambers had been cleaned by Dowell—and the fourth time that the operator had been well pleased with the results.

The high-pressure jet is used by Dowell engineers to spray the lateral openings between the bricks, in effect actually scrubbing the refractory surfaces with chemical solvents. The size and shape of the checkerworks seem to have no bearing on the effectiveness of the jet.

Dowell engineers have had extensive experience in cleaning industrial equipment with chemical solvents. Almost every piece of equipment found in blast furnace gas cycles and open hearth furnaces has been cleaned by Dowell. As a matter of fact, some have been cleaned while in actual operation.

Call a Dowell engineer to discuss your maintenance cleaning problems. He'll be glad to make a cost estimate on cleaning your equipment with chemicals. If you prefer, write directly to Tulsa, Dept. F-29.

DOWELL SERVICE

Over 100 Offices to Serve You with Chemical Cleaning for:

Boilers • Condensers • Heat Exchangers • Cooling Systems
Pipe Lines • Piping Systems • Gas Washers • Process Towers
Process Equipment • Evaporators • Filter Beds • Tanks

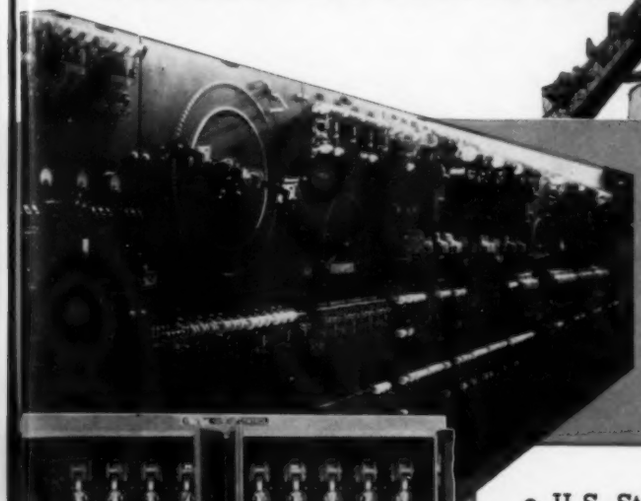
Chemical Services for Oil, Gas and Water Wells

DOWELL INCORPORATED • TULSA 1, OKLAHOMA

DOWELL

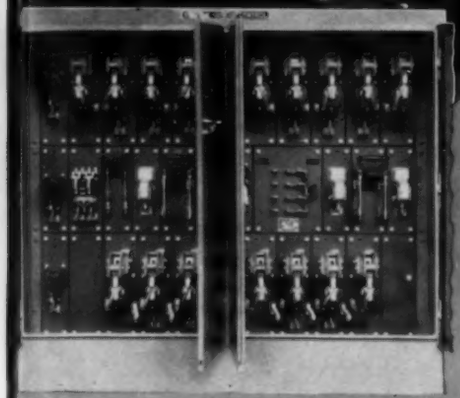
A Service Subsidiary of
THE DOW CHEMICAL COMPANY

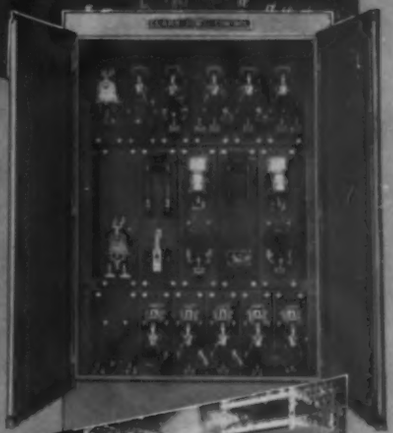
CLARK CONTROL *at* FAIRLESS WORKS



Control panel for Side Trimming and Shearing Line.

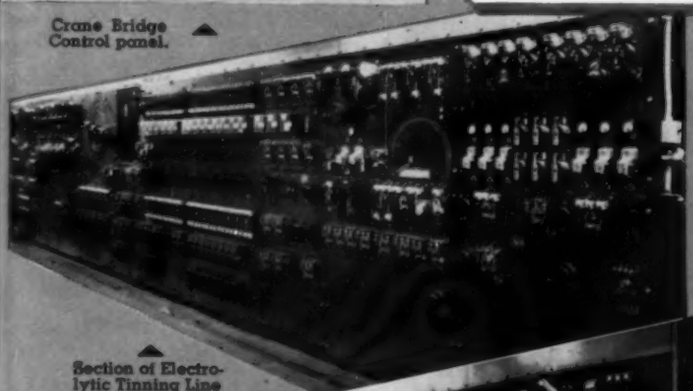
Control for Aetna-Standard 40" Side Trimming and Recoil Line.





• U.S. Steel uses CLARK control equipment for dependable electric control of many of its vital production operations at The Fairless Works. Shown here are some of the CLARK control panels in this gigantic mill . . . Steel mill control is a CLARK specialty and the Fairless Works installations are further proof of the confidence large steel producers place in CLARK engineering and CLARK equipment.

Crane Bridge Control panel.

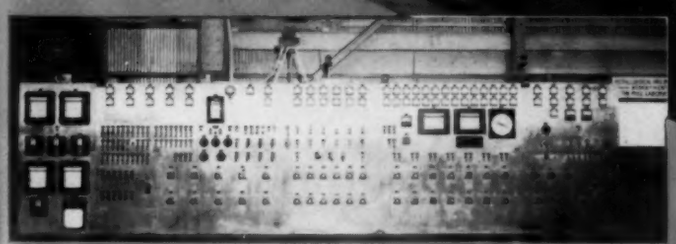


Crane Hoist Control panel.

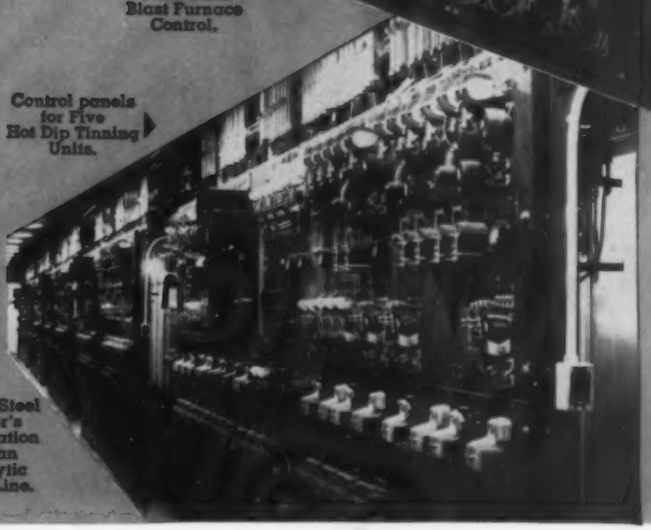
Section of Electrolytic Tinning Line DC Control.

Freyn-design Clark-built Blast Furnace Control.

Control panel for AC Auxiliaries for Tinning line.



Control panels for Five Hot Dip Tinning Units.



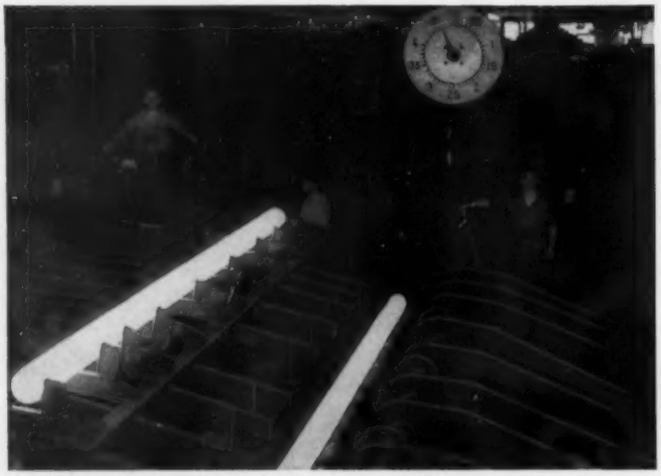
Stainless Steel operator's control station for Wean Electrolytic Tinning Line.

The CLARK CONTROLLER Company

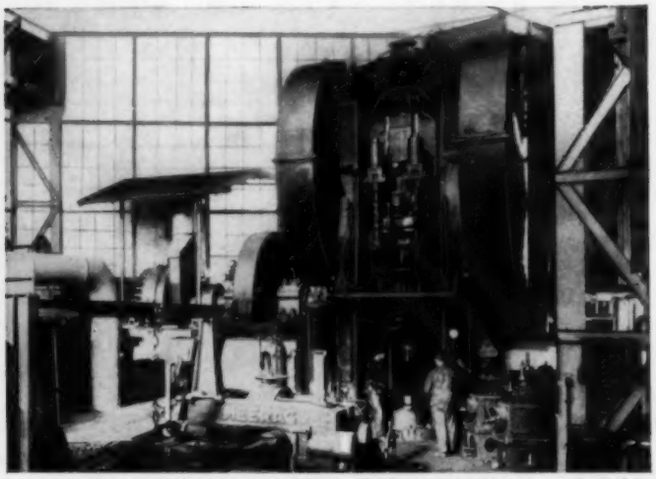
ENGINEERED ELECTRICAL CONTROL

1146 EAST 152nd STREET • CLEVELAND 10, OHIO

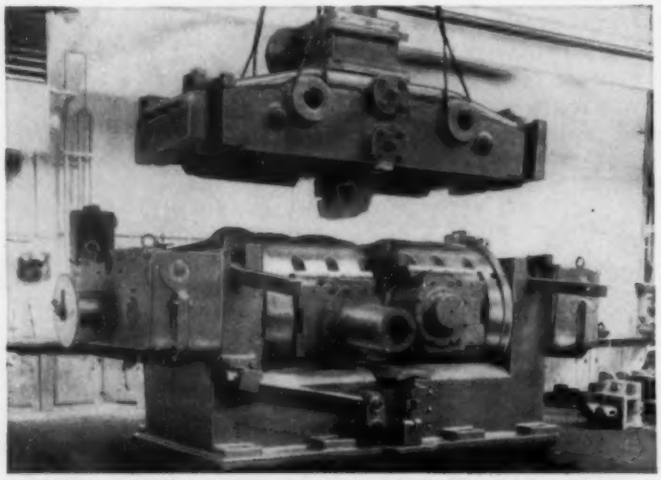
New mill machinery speeds seamless tube production



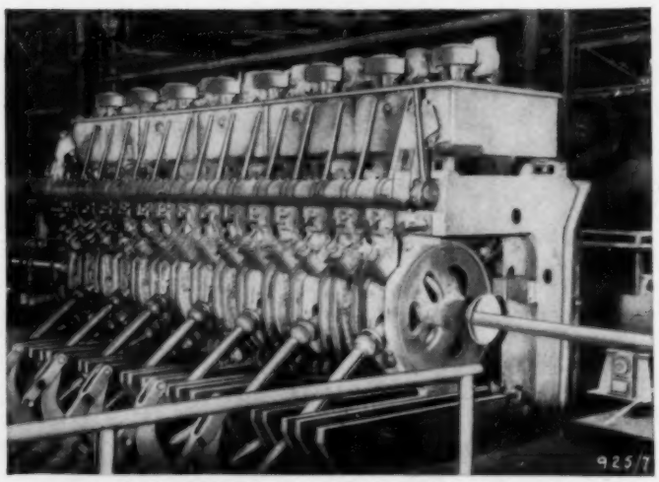
HIGH OPERATING SPEED of Mannesmann-Meer automatic return mill boosts production, cuts costs in any automatic mill plant. Special guides in mandrel bed aid quick changeover of schedules.



180 STEEL TUBES PER HOUR — that's the production record of this mechanical extrusion press. We also offer high-speed hydraulic extrusion presses for the non-ferrous industries.



HEAVY-DUTY REELER WITH ROLL OBLIQUITY adjustable in both planes, has individual motor drive for each roll. Permits use of a plug of any taper for any desired expanding action. All Mannesmann-Meer reelers are extra heavy and rugged in construction with anti-friction bearings throughout to assure best possible rolling conditions.



INCREASE OD REDUCTION at each three-roll stand on this stretch-reducing mill. New low-cost group drive permits speed adjustment for each stand. Special stand changing device provides for quick schedule change. These same features are available for continuous mandrel mills. Many outstanding design features are also available for both sinking and sizing mills.

Got production bottlenecks on seamless tubes?

At Mannesmann-Meer you'll find complete mills or mill machinery designed and built specifically to speed production and cut costs.

We're the *only* manufacturer of tube mill machinery who can draw on over 65 years of experience in the *operation* as well as the design of complete seamless mills. Let us put this production and engineering know-how to work for you.

Examples of some of our new developments in mill machinery are shown here. Mechanical and hydraulic extrusion presses — piercing mills — automatic return (plug) mills — continuous mandrel mills — heavy-duty reelers — assel mills — pilger mills — expanding mills — sizing mills — stretch-reducing mills — large electric weld pipe mills — rotary straighteners — tube reducing machines — are but a few of the many products in our complete line.

MANNESMANN-MEER

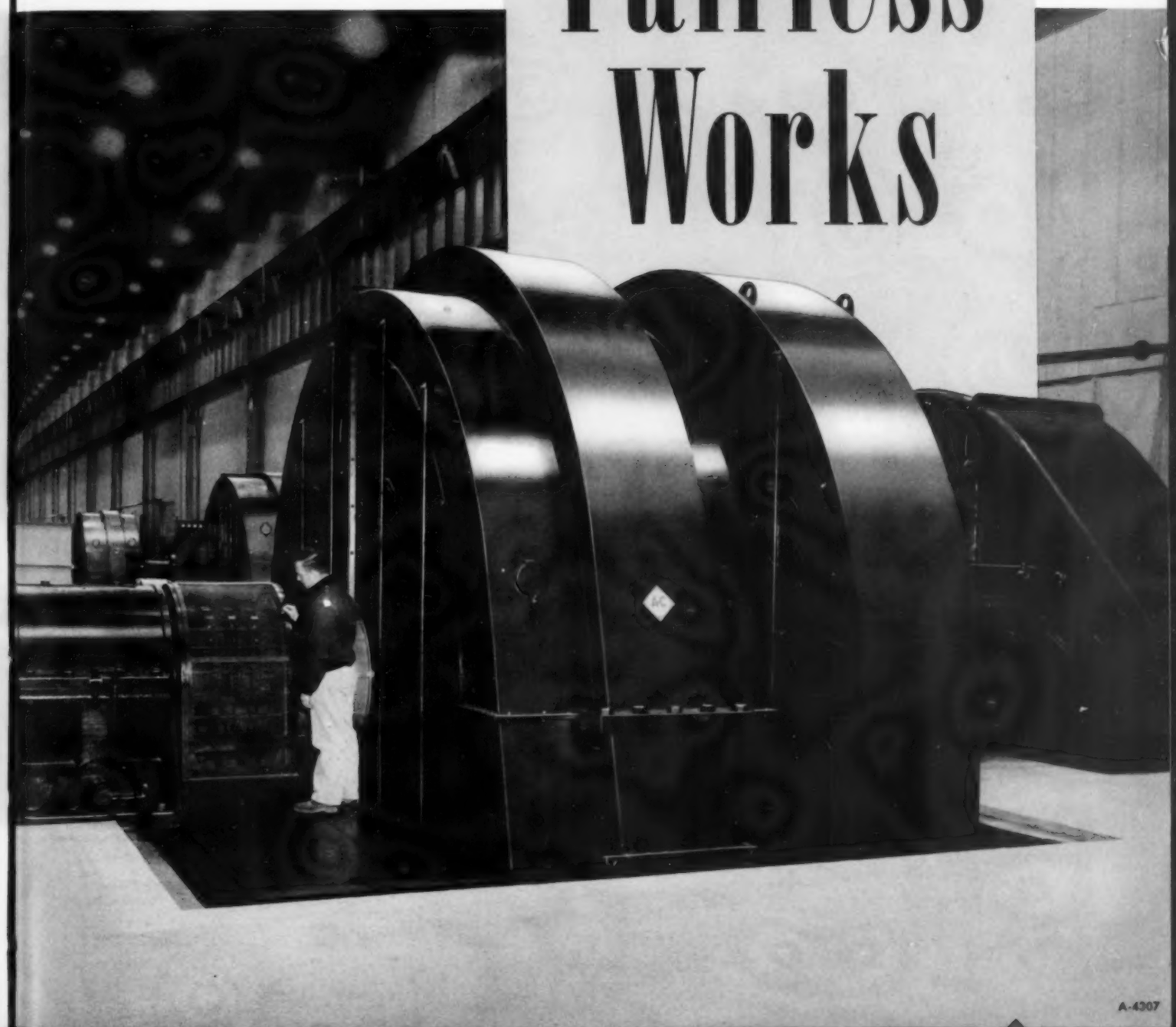
ENGINEERING & CONSTRUCTION COMPANY

900 Line Street, Easton, Penna.

WORLD SPECIALISTS IN HIGH-SPEED TUBE-MILL MACHINERY

Allis-Chalmers Equipment for Steel Mill Duty at...

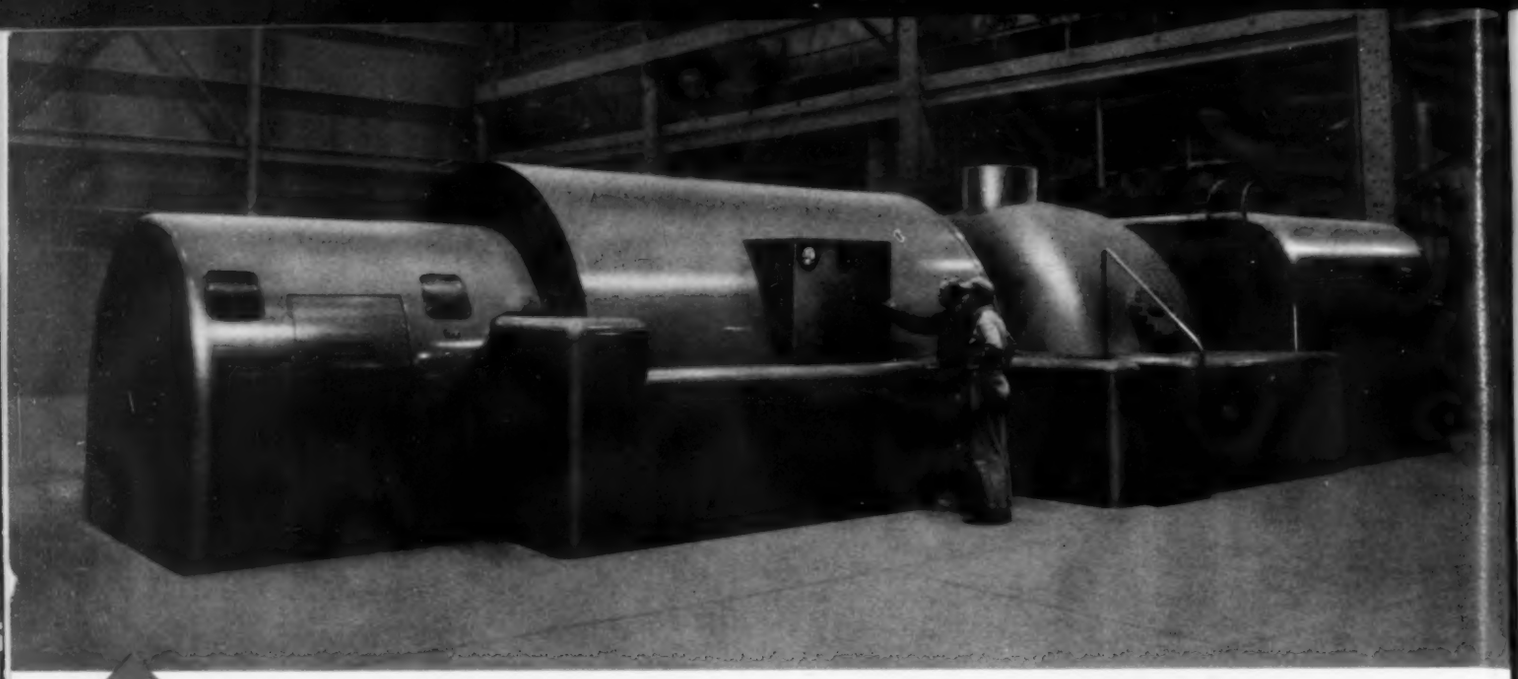
Fairless Works



A-4307

ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN



33,000 kw of steam-electric power for Fairless. Turbine features include accessibility of stop and inlet valves, centralized operating controls, self-contained and automatic steam-sealed gland system, above-the-floor oil piping and effective control of horizontal and vertical thermal movements. The generator offers simplified hydrogen seals and control, spiral stator ventilation, flexible core mounting, and "walk-in" exciter housing.

Double-armature twin drives power this two-stand tin temper mill. Driving the No. 1 stand at left are four 150-hp dc armatures. Four 200-hp armatures comprise the No. 2 stand drive at right.

Another Allis-Chalmers first . . . voltage, current and tension regulation of the two-stand tin temper mill is provided by magnetic amplifiers which offer the most modern refinements to the control circuits.

ALLIS-

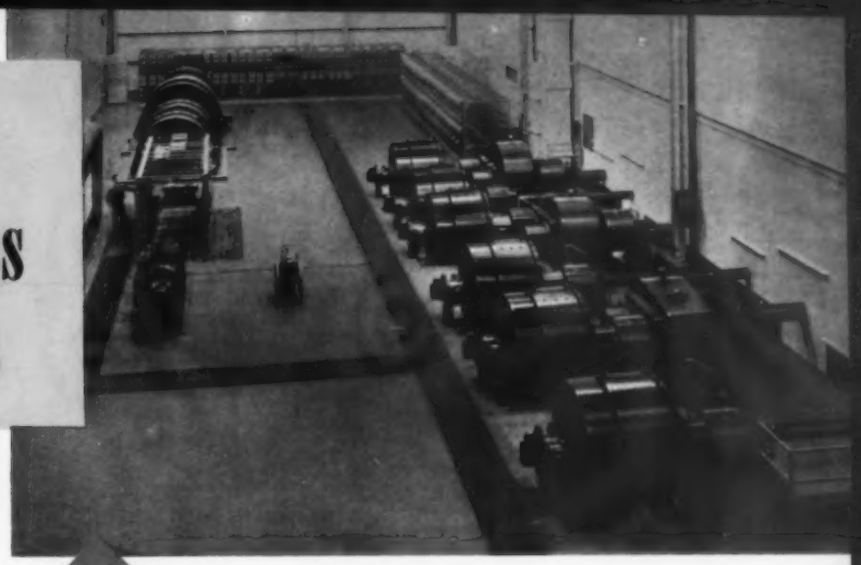
Serving Fairless Works

U.S. Steel Corporation's new integrated steel plant in the Delaware Valley, engineered for modern mill operations . . . produces its own coke, iron and steel as well as finished steel . . . is one of the largest plants of its kind in the world.

Again, as in other important mills of this vital industry, Allis-Chalmers was called upon to furnish a wide variety of equipment designed for steel mill duty.

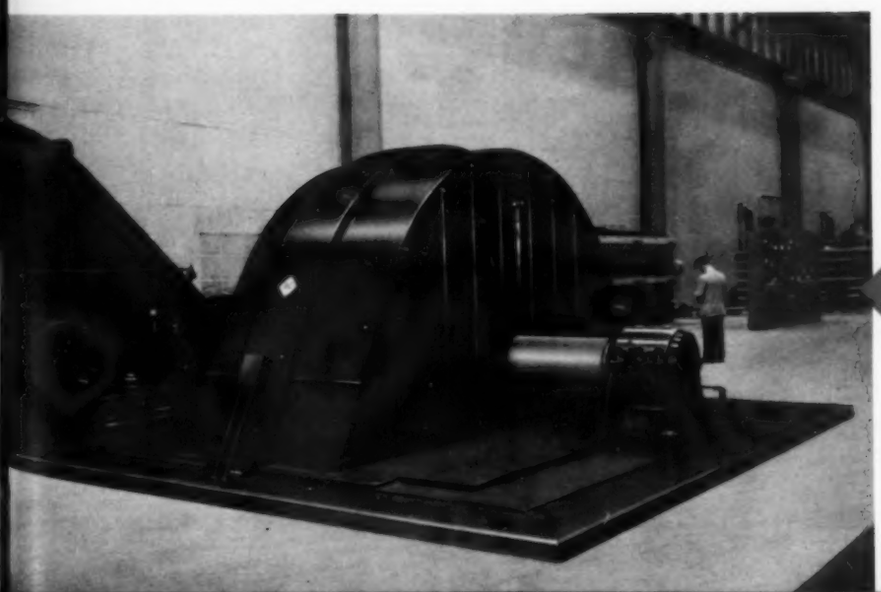
Rolling steel requires tremendous power, a part of which is produced by an Allis-Chalmers 33,000-kw turbine generator unit. *All* 250-volt direct current for material handling . . . from ore to finished steel . . . is supplied by A-C rectifier units totaling 25,000 kw and located throughout the plant for maximum efficiency. Important rolling operations for billet mills, hot strip mill, and the two-stand tin temper mill are accomplished with controls, motors and generators designed and built by Allis-Chalmers.

For specific information on controls, drives and other electrical equipment to meet the needs of your expansion or conversion program, contact the nearby A-C office or write to Allis-Chalmers, Milwaukee 1, Wisconsin.



Allis-Chalmers controls, motor-generator sets, and drive motors for the 30-in. billet mill. Left background shows the 8000-kw m-g unit powered by an 11,200-hp synchronous motor, variable voltage control panel, and a 3-unit 180-kw exciter m-g set. The six drive motors are rated 1750 hp, 300/600 rpm, 600 volts dc.

Four 1250-hp, 400/800-rpm, 600-volt dc motors driving four stands in the 21-in. continuous billet mill. Variable voltage controls, 4000-kw synchronous m-g set, and a 130-kw exciter m-g set for this mill were also furnished by Allis-Chalmers.

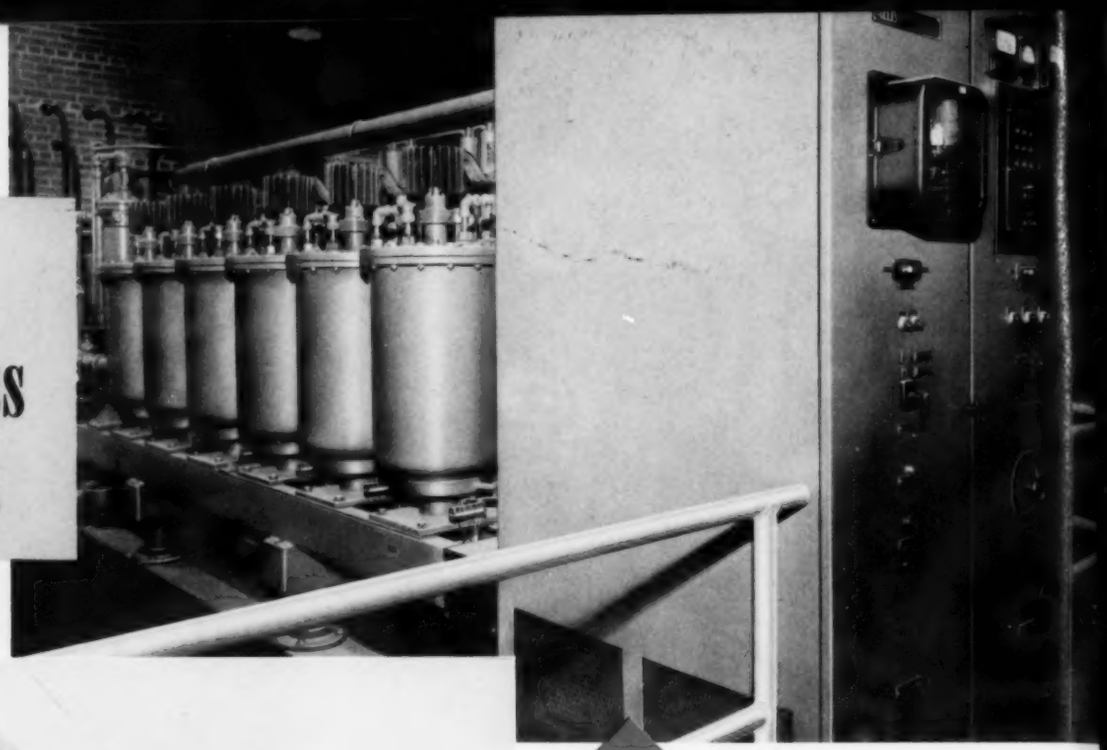


One of four universal roughing stand drives in the 80-inch hot strip mill. Operating in conjunction with the 3500-hp broadside wound rotor motor shown on the cover, these four 6000-hp synchronous motors provide power for reducing large slabs. Other A-C motors in this mill include a 2000-hp synchronous scale breaking motor and two 500-hp wound rotor motors for a vertical edger.

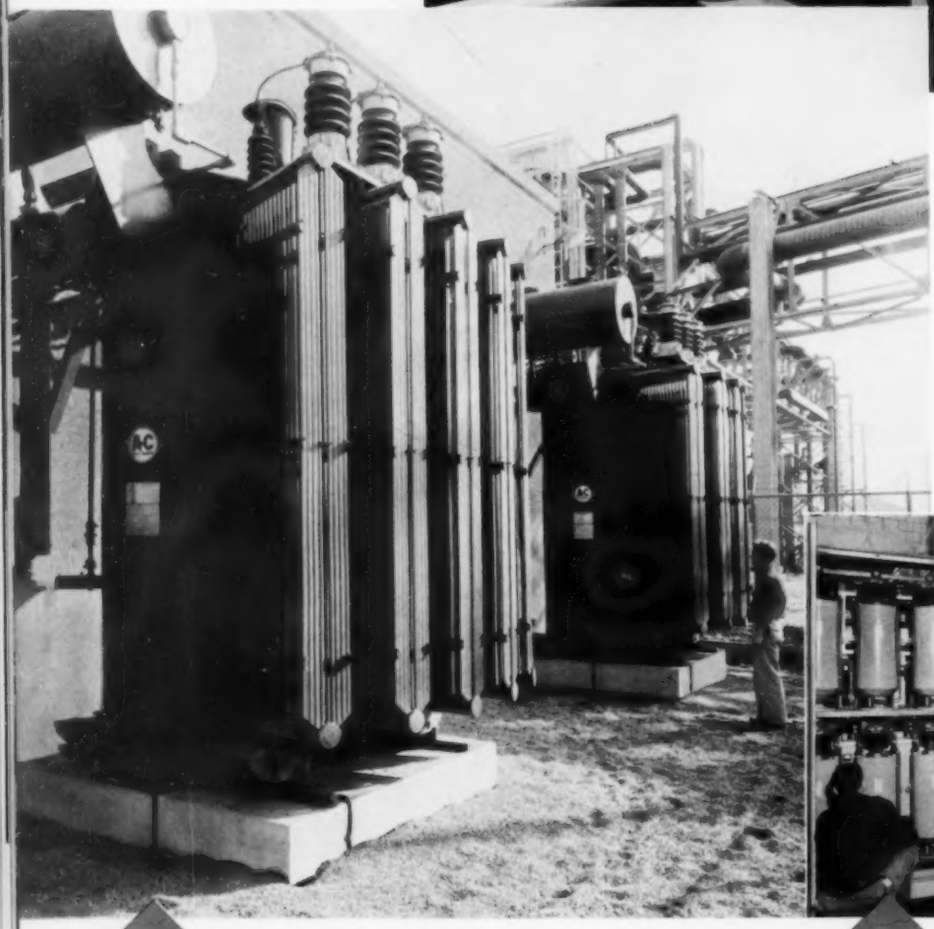
-CHALMERS A-C ALLIS-CHALMERS

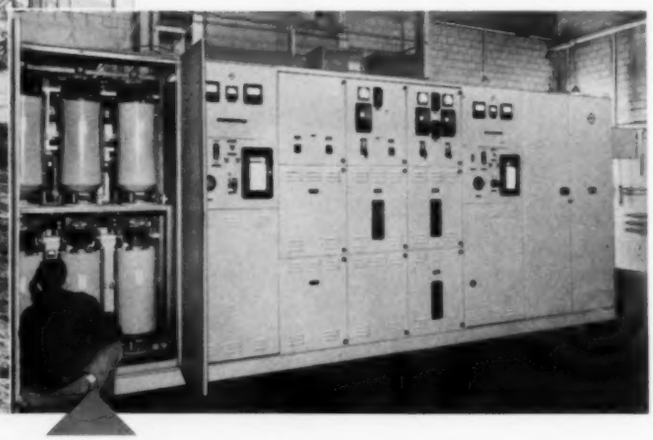
Serving

Fairless Works



One of two 1500-kw, 250-volt rectifiers supplying direct current to cranes, pig casting machines, bailer, slag cars, and stock house equipment in Open Hearth Furnace area. Each unit substation is designed for a three-phase, 13,800-volt, 60-cycle supply and is suitable for starting and stopping by manual or remote control.





Outdoor type main transformers for two 1500-kw, 250-volt rectifier units in the Open Hearth area. These transformers are oil insulated self-cooled, with built-in interphase reactors, and are provided with ground level tap changers for ease of operation, and broad flanged wheels for use on rails or flat surfaces.

Two 500-kw, 250-volt metal-clad rectifier units supplying dc service to coke plant pusher and coke handling equipment in the Coke Oven area. Units are factory assembled and wired, complete with dc switchgear and transformers. Both rectifier units feed a common load, providing maximum availability at all times.

ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

Partners in achievement...

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WEAN EQUIPMENT CORPORATION
Cleveland, Ohio

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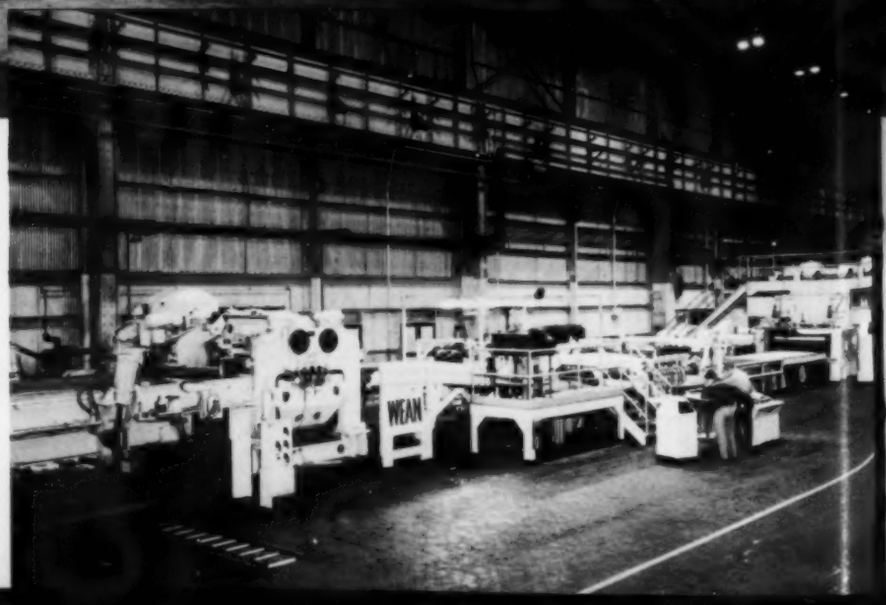
Milan, Italy

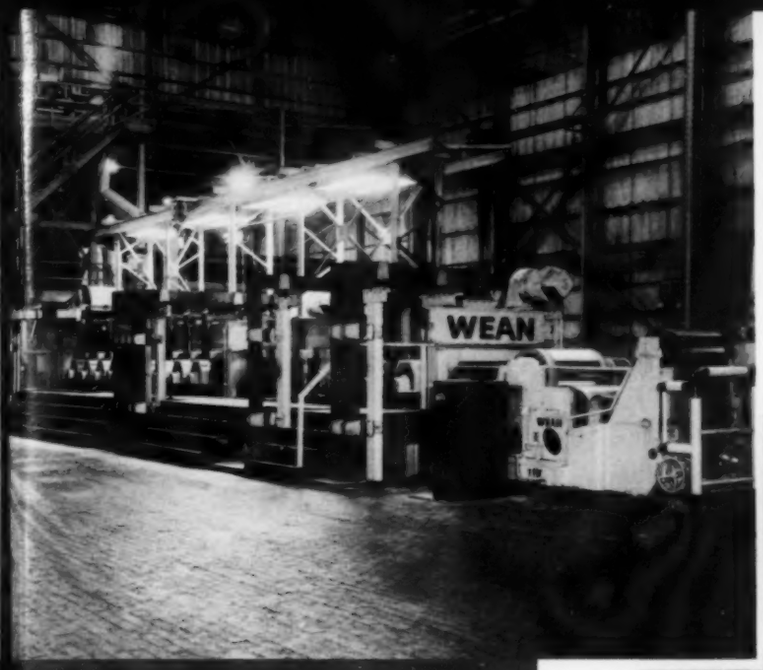
WEAN ENGINEERED...

and built steel strip production equipment in operation at the Fairless Works of the United States Steel Corporation

Wean 74"-wide continuous high-speed STRIP PICKLER with temper mill.

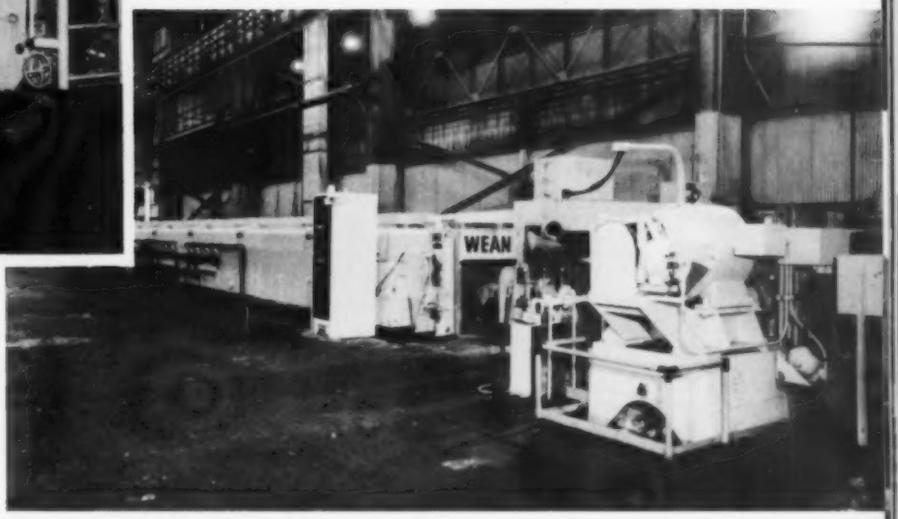


Wean 74" HOT STRIP SHEARING and PROCESSING LINE including following operations: process uncoiling, side trimming or slitting, temper rolling, coiling or cutting-to-length, leveling and classifying and piling.



Wean-Ferrostan Electrolytic Tinning Line.

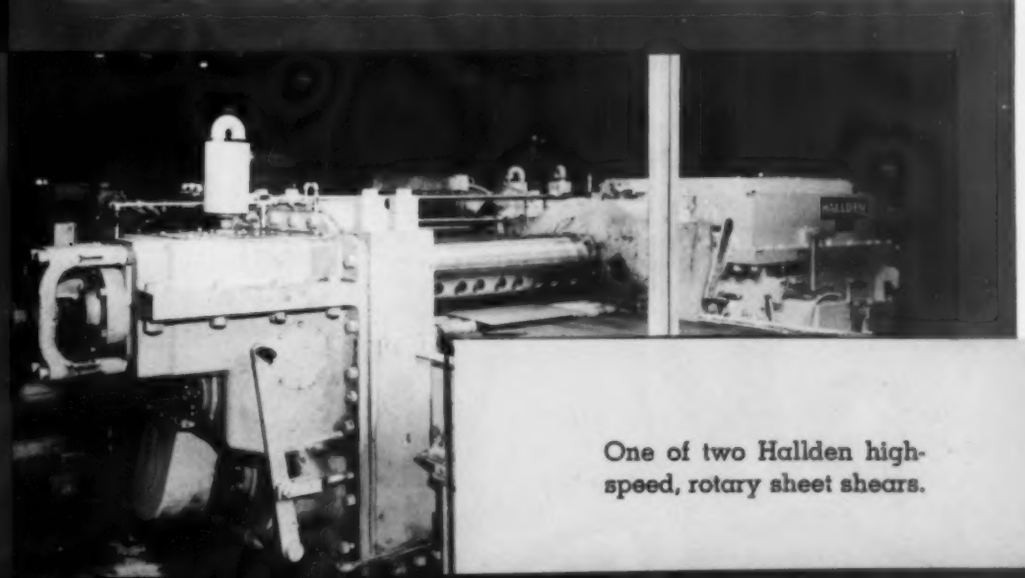
Wean 48" Electrolytic Cleaning Line for sheet strip and tin plate.



The United States Steel Corporation points with just pride to the Fairless Works as the world's most modern steel making facility. Wean Engineering Company, Inc., is proud to have been a "partner" in this great new chapter of production achievement.

From its conception the Fairless Works was intended as the ultimate in modern steel production. From raw material receiving to finished steel shipping, every station was carefully analyzed to make certain that the most advanced, yet practical, methods were adopted.

Concentrating on the production of strip sheets and tin plate at faster speeds, while actually improving quality, U. S. Steel selected the Wean Engineering Company, Inc., to design and build Pickle Line Equipment, a Hot Strip Shearing and Processing Line, an Electrolytic Cleaning Line, Electrolytic Tinning Line Processing Equipment and the Cold Strip Flying Shears (Hallden) pictured on these pages.



One of two Hallden high-speed, rotary sheet shears.

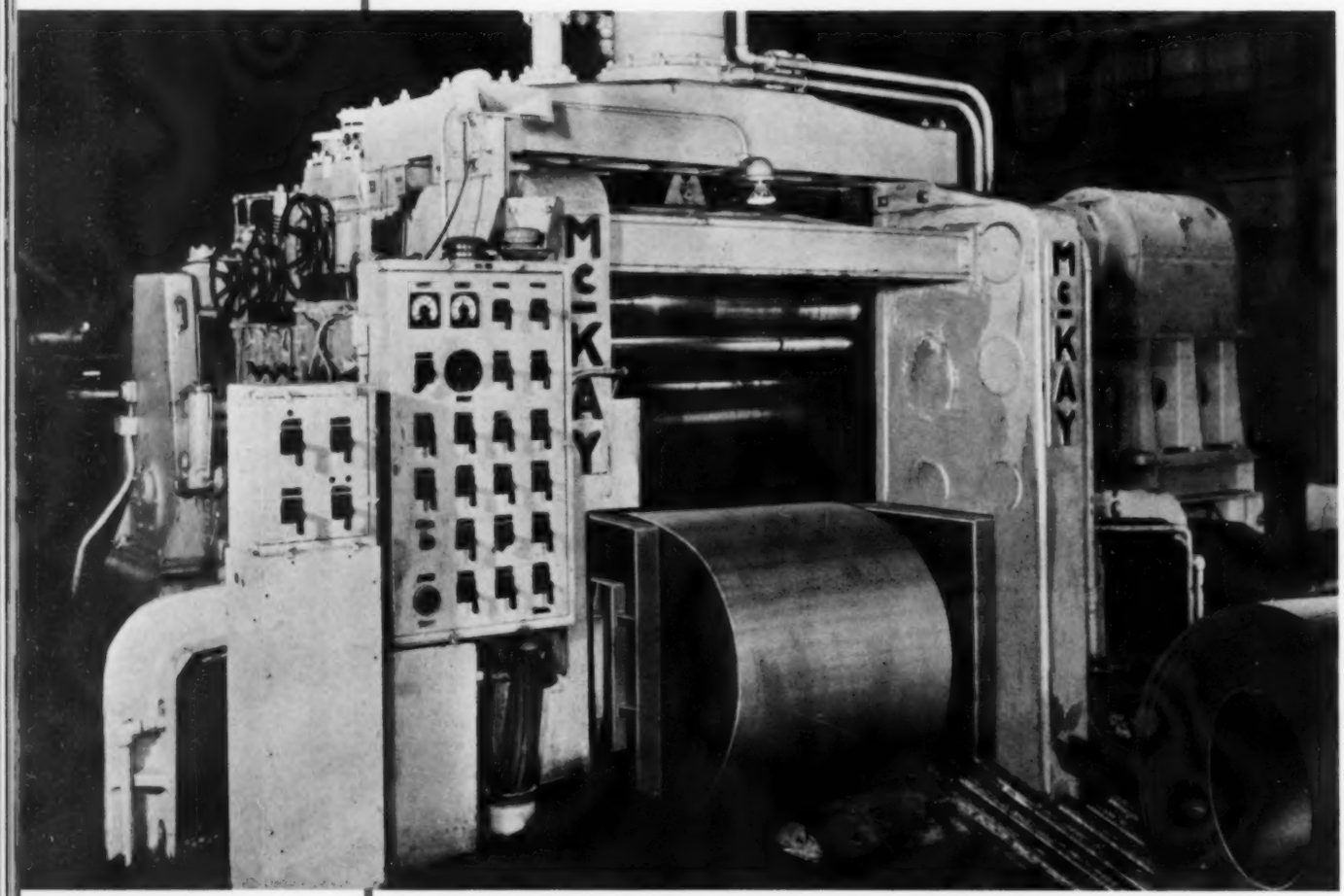
The WEAN ENGINEERING CO. INC.
Warren, Ohio

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT.

McKAY

ENGINEERS AND DESIGNERS OF EQUIPMENT FOR THE AUTOMOTIVE, FABRICATING AND STEEL INDUSTRIES

The McKay Heavy Duty Machine shown below permits uncoiling hot rolled material up to 1500 ft. per minute.



Building a plant for the future requires equipment that anticipates future demands.

When designing "The Fairless Works" — the U. S. Steel Corporation insisted on equipment that would satisfy future requirements.

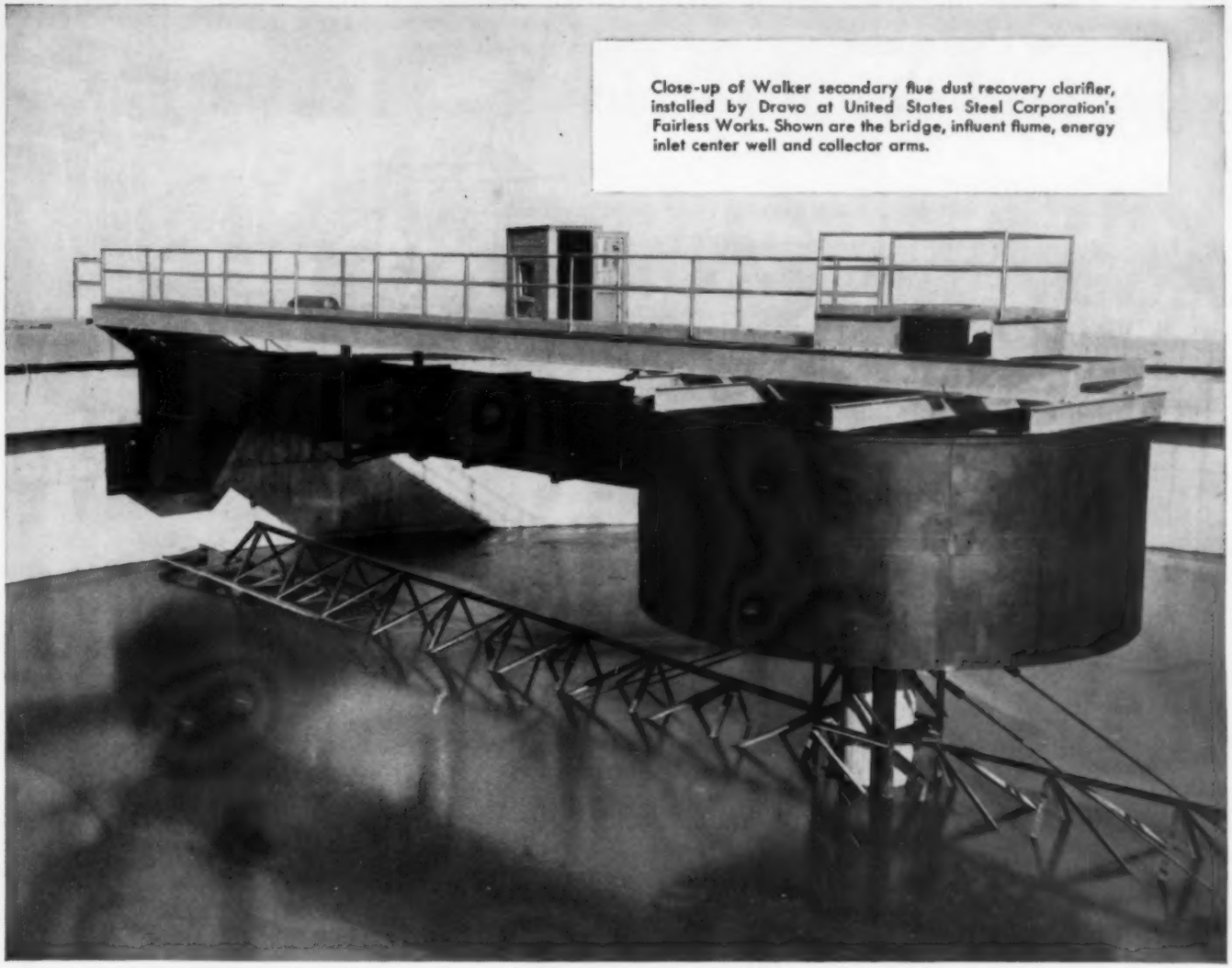
For this "mill of tomorrow" the McKay Machine Company has supplied the processing uncoiler (illustrated above) and the upcoiler in the Wean 74" Continuous Strip Pickle Line.

The Wean 74" Strip Shearing and Processing Line also includes a McKay processing uncoiler and roller leveler.

We are proud of the faith displayed by U. S. Steel in their selection of McKay Equipment for this most modern steel mill.

THE McKAY MACHINE COMPANY
YOUNGSTOWN, OHIO

Litho in U.S.A.



Close-up of Walker secondary flue dust recovery clarifier, installed by Dravo at United States Steel Corporation's Fairless Works. Shown are the bridge, influent flume, energy inlet center well and collector arms.

DRAVO installs world's largest industrial waste treatment plant

Now at work in the new Fairless Works of the United States Steel Corporation at Fairless Hills, Pa., is the largest waste treatment operation ever installed. Dravo Corporation furnished and installed *three* Walker Process Plants to eliminate flue dust, oils and acids from waste water before it was returned to the Delaware River.

The secondary flue dust recovery plant consists of a *Walker Process Equipment Inc.* Clarifier, Flocculator, Mixer and a Lime Tower. Waste from the Walker Primary flue dust Clariflow Thickener is further processed here with lime prior to discharge.

The oil interception plant receives from the sheet and tin mill such waste as chromic acid, spent pickling solution, sodium silicate, oils and grease all of which are processed through a four-stage mixing system. Dravo supplied and installed the Walker Process mixers, flocculating clarifier, A.P.I. Separator and fabricated and erected the piping.

In addition to all waste water from the hot strip and tube mill, the terminal plant receives discharge from the oil interception plant. This waste is processed through aeration chambers to settling chambers and then pumped to the river.

This is just one of many ways in which Dravo supplies the steel industry with products and services. "Dravo Bulletin 1200-A" will further illustrate how Dravo can work for you. For your copy write to Dravo Corporation, Machinery Division, Fifth and Liberty Avenues, Pittsburgh 22, Penna.

DRAVO

DRAVO

CORPORATION

PITTSBURGH 22, PENNA.

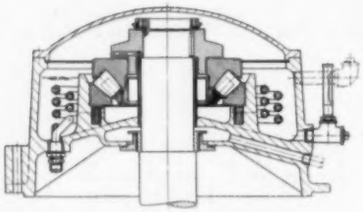
Sales Representatives in Principal Cities

traditional service **SKF**

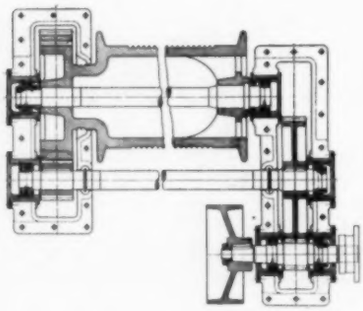
for the new **USS** TRADE MARK

Fairless Works

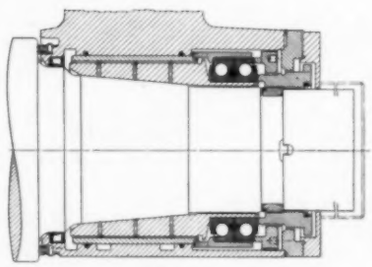
Steel's move to Delaware Valley is a *pioneering* move—
good for Steel, good for steel users.
Since 1907, SKF has pioneered along with America's
entire steel industry in applying the science of anti-friction
to more efficient mill operations. Here, for example, are
three outstanding SKF contributions to the Fairless Works—



The SKF Spherical Roller Thrust Bearings—installed on deep well pumps, un-coilers, and other equipment where there is a problem of heavy, high speed thrust loads.



The SKF Spherical Roller Bearings—provide longer bearing life for ingot cars, mill run-out tables, and cranes.



The SKF Double-Directional, Thrust Ball Bearings—with high thrust capacity for the grueling service of skelp mill operation.

Not only Steel but *every* industry has learned to look to SKF Engineers for the best ways to put the right bearing in the right place. 7549

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of **SKF** *and* HESS-BRIGHT® *bearings.*

SKF®
BALL AND ROLLER BEARINGS

Electrical and Mechanical Installation under PEC prime Responsibility

NEW CONTINUOUS BUTT WELD PIPE MILLS
Annual Capacity—281,000 Tons
and 10 STAND COILED SKELP MILL
NATIONAL TUBE DIVISION
Fairless Works
USS Corporation

Motor Room for Coiled Skelp Mill and Butt Weld Mills

(left)
10—DC Skelp Mill Roll Drive Motors with 2—3000 KW & 2—1000 KW Rectifiers (center)

(right center)
One of 2—1000 KW M-G sets for Butt Mill Roll Drives

Equipment layout by National Tube Engineers for most economical use of copper

No. 2 Continuous Butt Weld Mill. Both mills embody maximum use of stretch reduction principal.

Skelp and Butt Mill Installations required combined total of:
572,000 ft. steel conduit
2,385,000 ft. wire and cable

No. 1 Mill—½" to 1½"
No. 2 Mill—1¼" to 4"

ELECTRICAL INSTALLATIONS
PATTERSON EMERSON COMSTOCK, INC.
PITTSBURGH, PA.

PATTERSON-EMERSON-COMSTOCK, INC.
313 E. CARSON STREET • PITTSBURGH 19, PA. • EVergladе 1-9800

World's Heaviest Powered

Complete Mill Installation from Slabyard to Coiler under Prime Responsibility of

ELECTRICAL INSTALLATIONS PEC PITTSBURGH 1, PA.

Electrical Equipment

Combined total rating of roll drive and auxiliary motors, motor-generator sets and rectifier units installed and connected for operation of both mills exceeds:

Slabbing Mill	84,450 HP
Hot Mill	158,180 HP
Total Both Mills	242,630 HP

Wiring Materials Included:

503,000 Ft. Steel Conduit,
827,000 Ft. Wire & Cable,
20,000 Lbs. Copper Bus Bar,
350 Tons Miscellaneous Steel Fabrication.

Installation Time

Three days after award of construction contract, preliminary electrical work started.

Within one year after the first deliveries of equipment, the Hot Mill rolled and coiled the first slab. — and 64 days later the Slabbing Mill rolled its first ingot.

The construction period was restricted to a minimum under closely planned work schedules and well co-ordinated efforts of electrical, mechanical and piping crews.

Slabbing Mill Motor Room; 480 Ft. Long. 3 Roll Drive Motors Total 16,000 HP

Hot Mill Motor Room; 960 Ft. Long. 14 Roll Drive Motors Total 59,500 HP

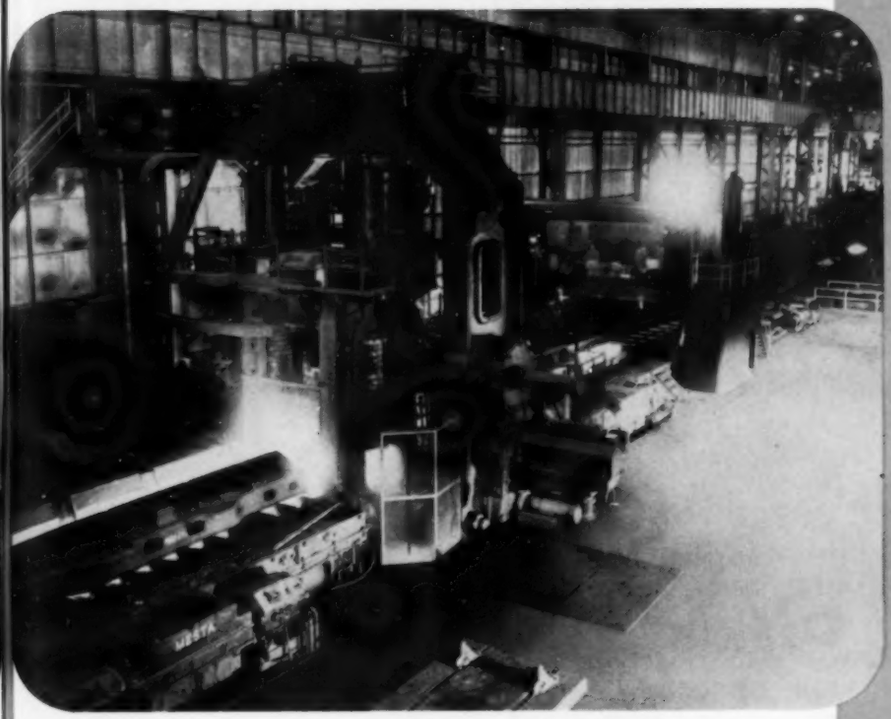
Electrical Installation
by
PATTERSON-EMERSON-COMSTOCK, Inc.
Pittsburgh 19, Pa.

Mechanical Erection
by
EICHLEAY CORPORATION
Pittsburgh 19, Pa.

Piping Systems by
BLAW-KNOX COMPANY
Power Piping and Sprinkler Division
PITTSBURGH 33, PA.

Steel Mills

45" x 90" Slabbing Mill
80" Hot Strip Mill
UNITED STATES STEEL CORPORATION
Fairless Works, Fairless Hills, Pa.

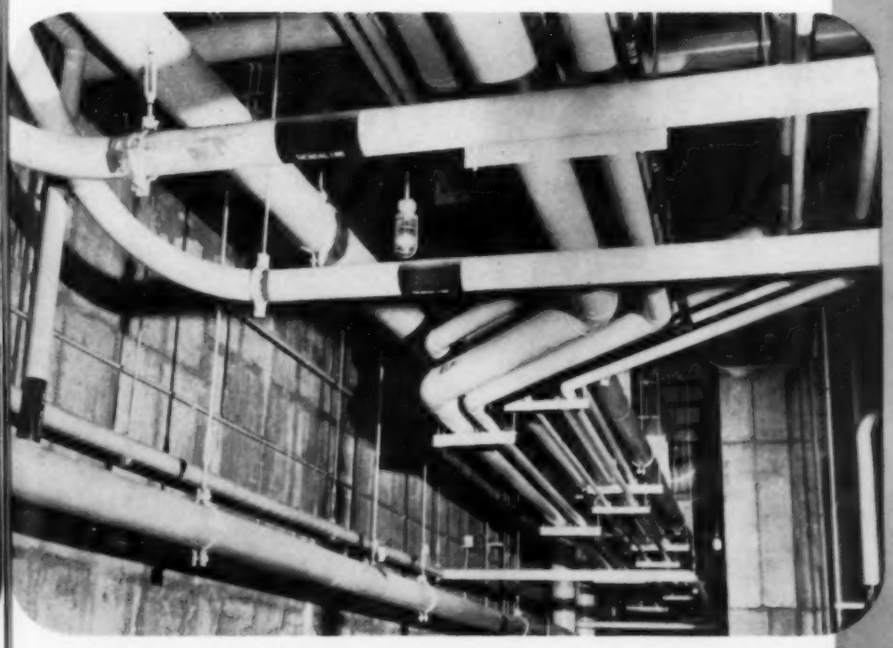


45"x 90" Slabbing Mill

Mechanical Installation
BY EICHLEAY

A total of 26,000 tons of machinery was precision installed. All major mill components and auxiliaries for both the Mesta 45" x 90" Slabbing Mill and 80" Hot Strip Mill were erected on a rigidly maintained schedule.

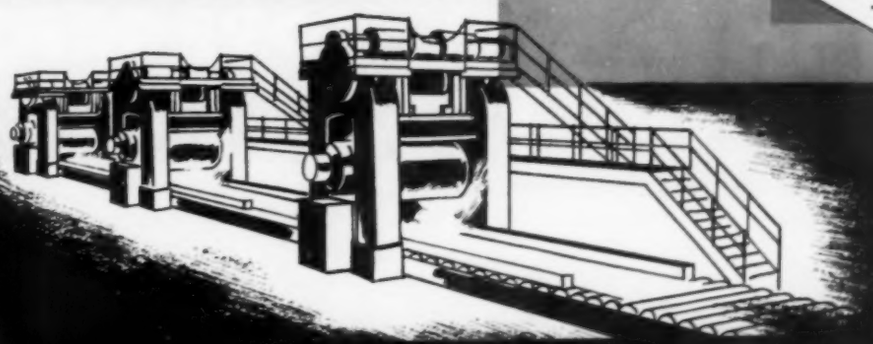
EC



Mill Piping Systems
by
Power Piping and Sprinkler Division
BLAW-KNOX COMPANY

Piping in the oil cellar of the 80" hot strip mill is typical of the high pressure piping . . . fabricated and erected by Blaw-Knox . . . for both the hot strip mill and the 45" x 90" slabbing mill in the most modern plant of the United States Steel Corporation.

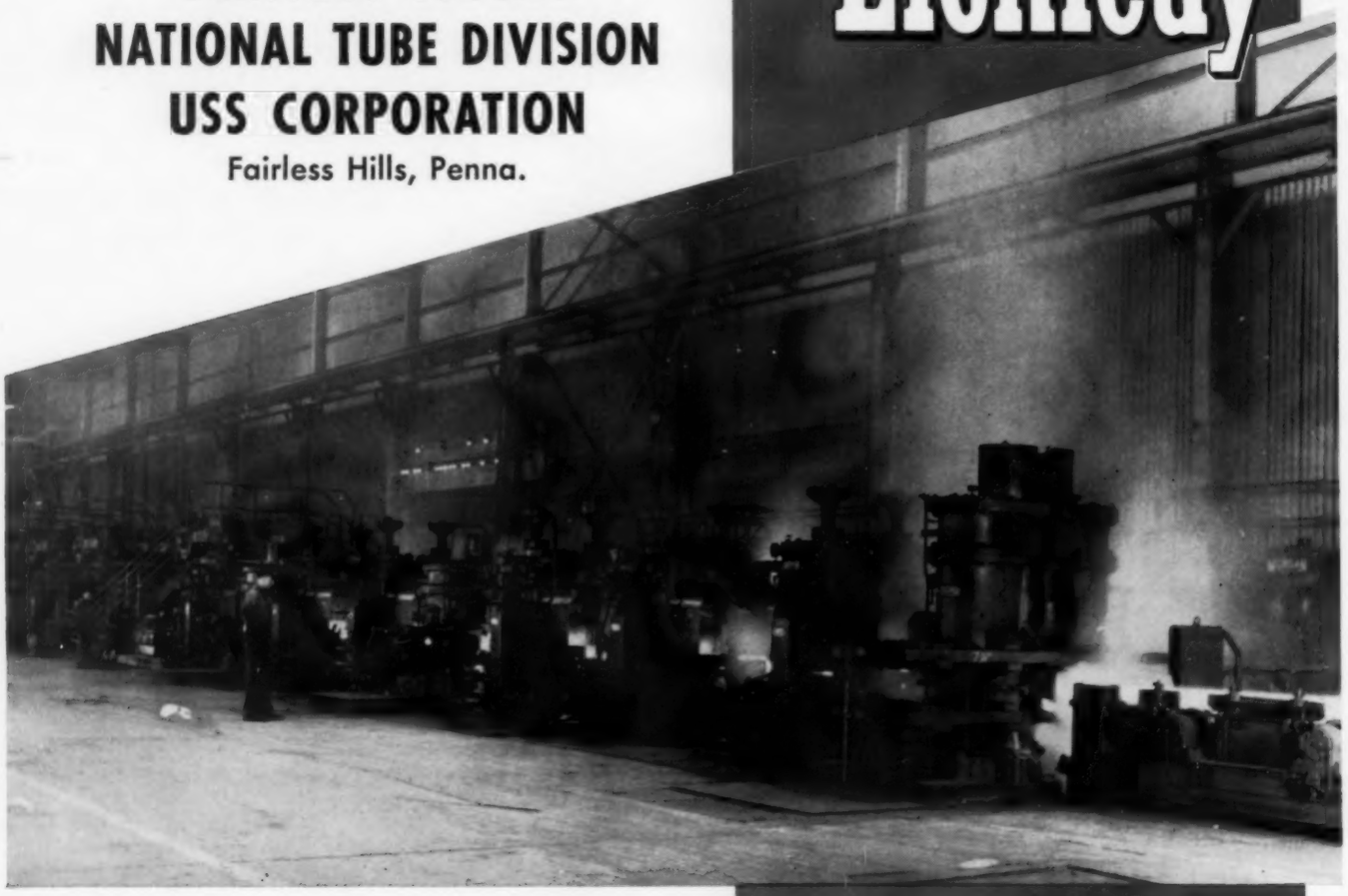
BLAW-KNOX



Mechanical Installation
Fairless Works
NATIONAL TUBE DIVISION
USS CORPORATION

Fairless Hills, Penna.

by Eichleay



We are happy to have been of service to the National Tube Division of the U S S Corporation at the great new Fairless Works, Fairless Hills, Pa.

Our work included the mechanical installation of the Morgan 10 Stand Skelp Mill and two Aetna-Standard Continuous Weld Pipe Mills—one ½" to 1½" Mill and one 1½" to 4" Mill—together with all auxiliary equipment for these mills. Over 6,000 tons of mill equipment was mechanically installed.

EICHLEAY SERVICES

- Complete Plant Erection
- Relocation of Industrial Units
- Structural Steel Erection
- Foundations for Buildings and Equipment
- Installation of Industrial Equipment
- Building Moving
- Shoring, Rigging

EC

Eichleay

ESTABLISHED 1873

CORPORATION

33 South 19th St., Pittsburgh 3, Pa.

681 Market St., San Francisco 5, Calif.

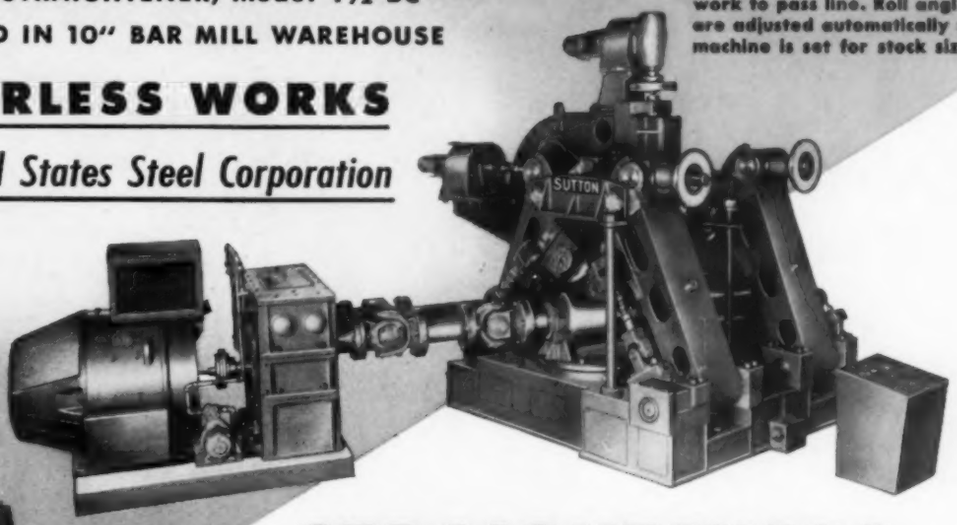
SUTTON STRAIGHTENER, Model 1½ BC
NOW USED IN 10" BAR MILL WAREHOUSE

FAIRLESS WORKS

United States Steel Corporation

NEW SUTTON SEVEN ROLL STRAIGHTENER

For bars and tubes. Two 3-roll clusters positively confine work to pass line. Roll angles are adjusted automatically as machine is set for stock size.



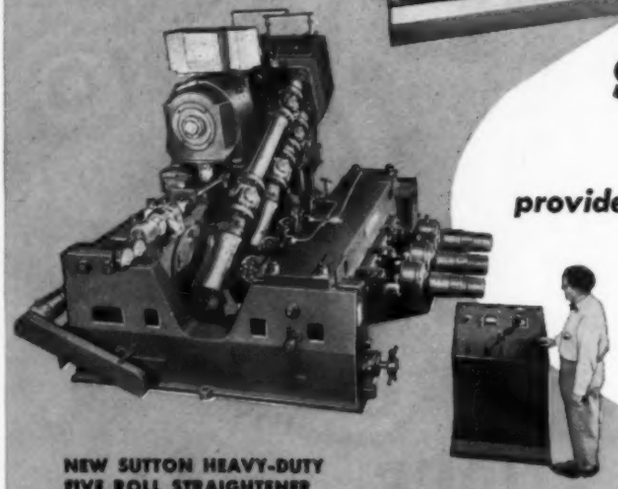
STRAIGHTENERS

BY SUTTON

provide **... SPEED ... PRECISION ... DEPENDABILITY**

You get the advantage of our years of specialized experience with every installation. Sutton Straighteners are built in all sizes for bars and tubes from ⅛" to 18" in diameter. They operate at speeds up to 1000 feet per minute.

Ask us for a proposal or for specific information about any straightening need you may have. There is no obligation for this service.

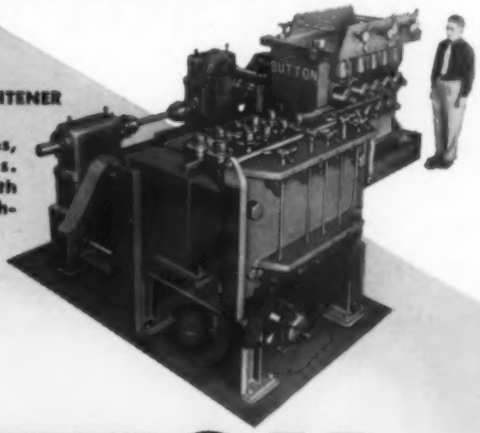


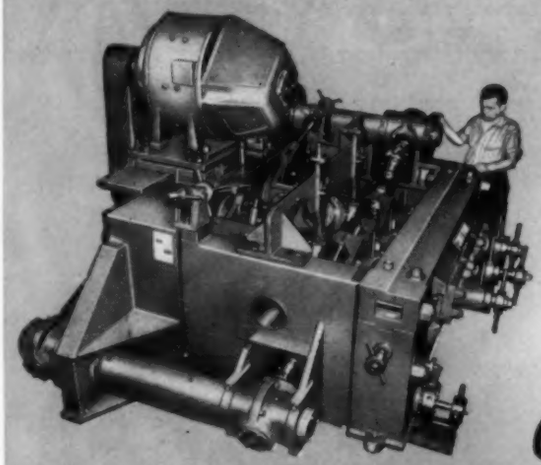
NEW SUTTON HEAVY-DUTY FIVE ROLL STRAIGHTENER

For bars and tubes. Screw-downs and roll angling adjustments are power operated.

NEW SUTTON TWO-PLANE STRAIGHTENER

For flats, squares, hexagons, angles and other shapes. Heavy duty construction with anti-friction bearings throughout.





NEW SUTTON FIVE ROLL STRAIGHTENER AND POLISHER

For cold drawn bars. Has four driven rolls. Exceptionally good for high-speed work.

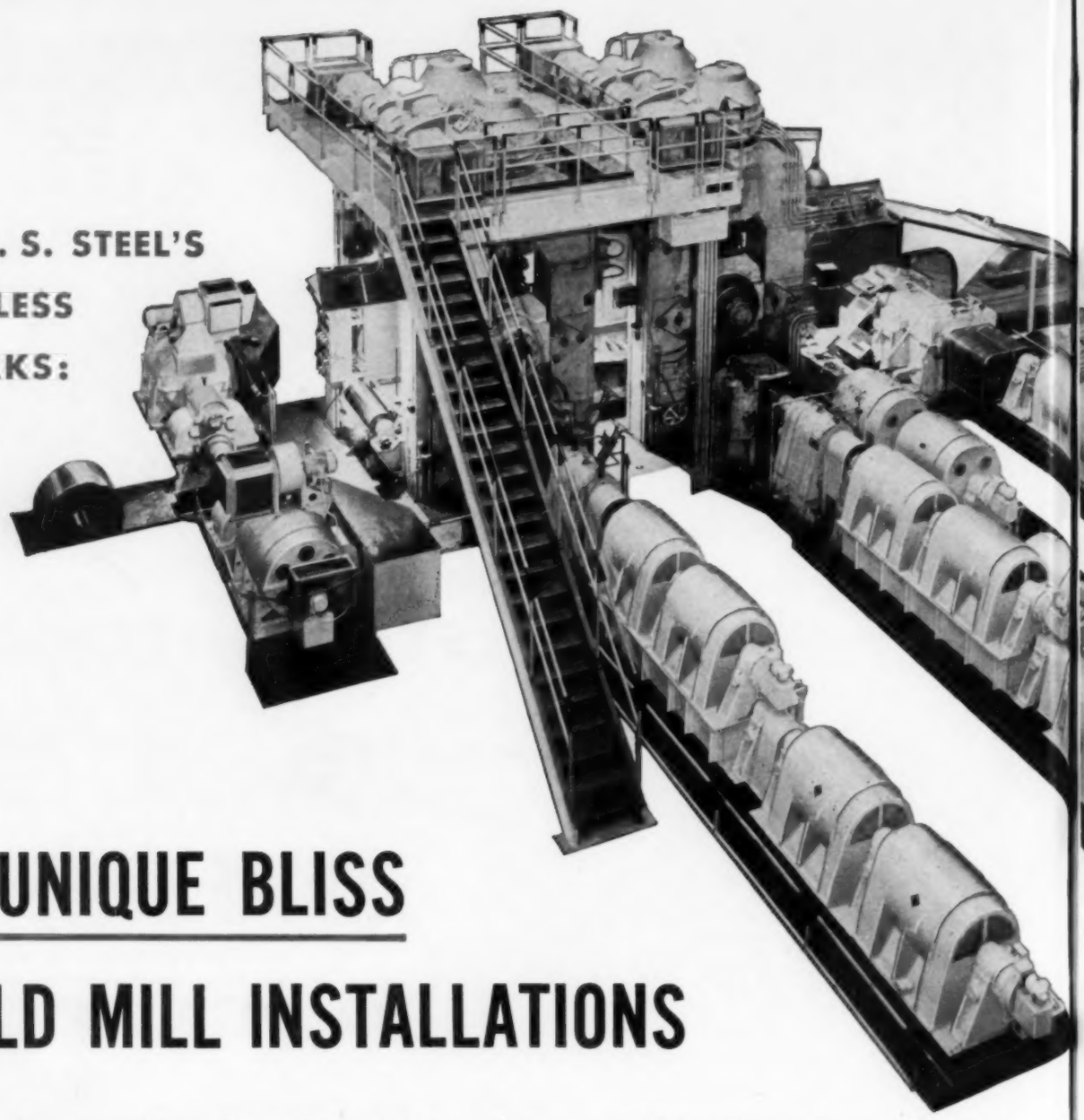
SUTTON *Engineering* COMPANY

Manufacturers for **Ferrous and Non-Ferrous Industries**

STRAIGHTENERS, SHEET LEVELLERS, HYDRAULIC STRETCHERS, GAG PRESSES, ROTARY CLEANERS, HEAVY DUTY UNIVERSAL JOINTS, ROLLS

BELLEFONTE, PENNSYLVANIA

AT U. S. STEEL'S
FAIRLESS
WORKS:



3 UNIQUE BLISS COLD MILL INSTALLATIONS

Three interesting rolling mills catch a visitor's eye at the Fairless Works: the big, fast Two-Stand Tandem Mill that temper rolls tin plate; the Two-High Mill built right into the Wean pickling line to pulverize oxide on the hot rolled strip and thereby speed pickling; and another Two-High Mill in the Wean Shearing line which tempers, trues-up and flattens strip—eliminating extra handling steps.

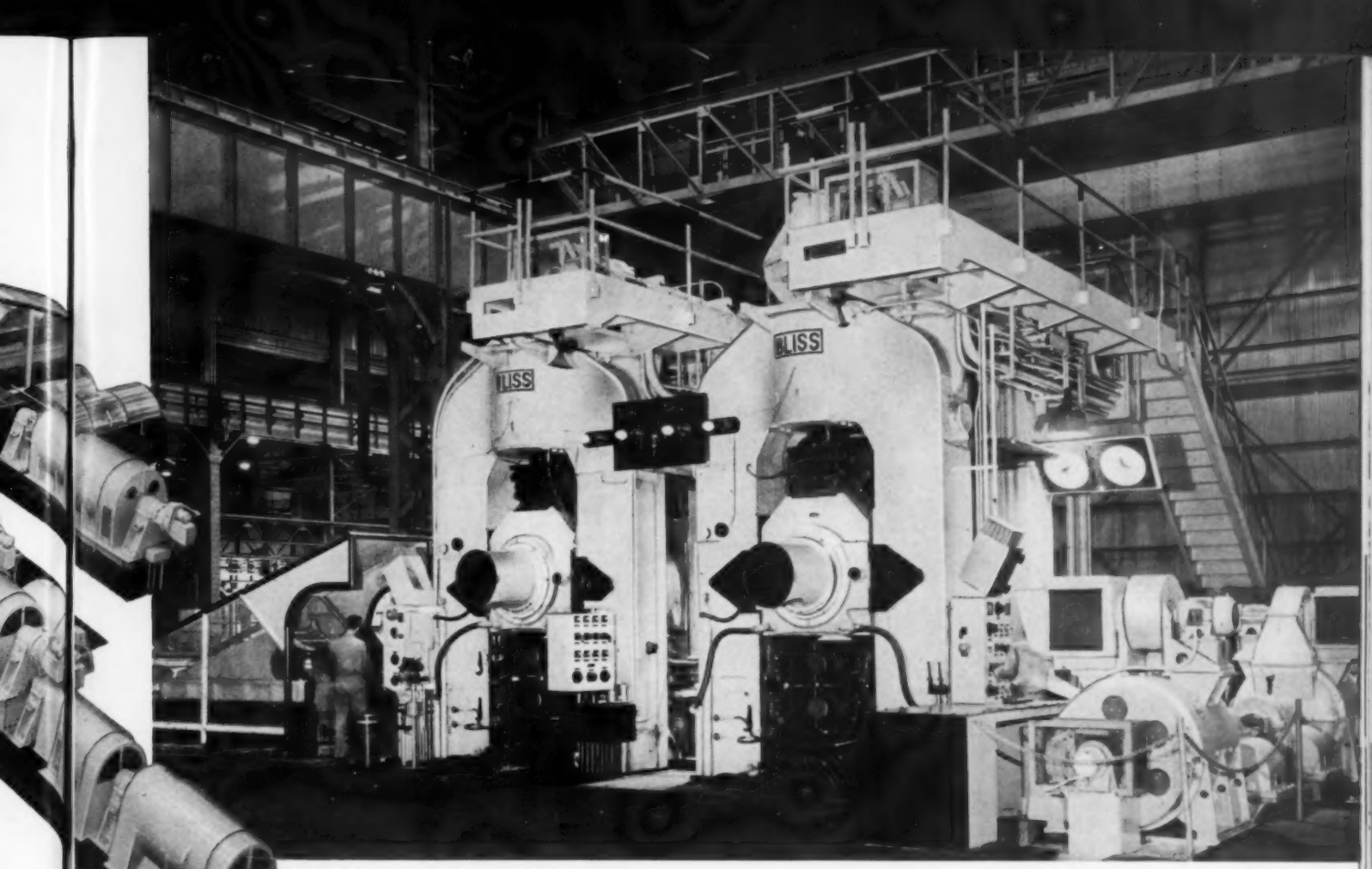
Each of the mills is Bliss-Built—all are the result of close cooperation between Bliss rolling mill engineers and U. S. Steel's top engineers and operating men. And each of the three mills encompasses the most advanced thinking in design, material handling and instrumentation for speed, safety and quality control. If you'd like to see other examples of modern Bliss rolling mill equipment and accessories, write for a copy of our new 60-page Rolling Mill Brochure today. Ask for catalog 40-A.

E. W. BLISS Company
General Office: Canton, Ohio

BLISS
SINCE 1832

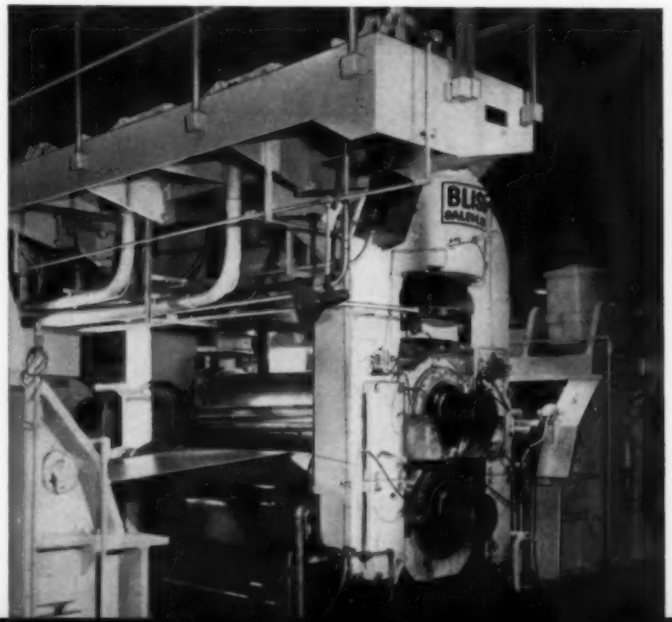
ROLLING MILL DIVISION: SALEM, OHIO

Remember: BLISS for Presses, ROLLING MILLS, Special Machinery

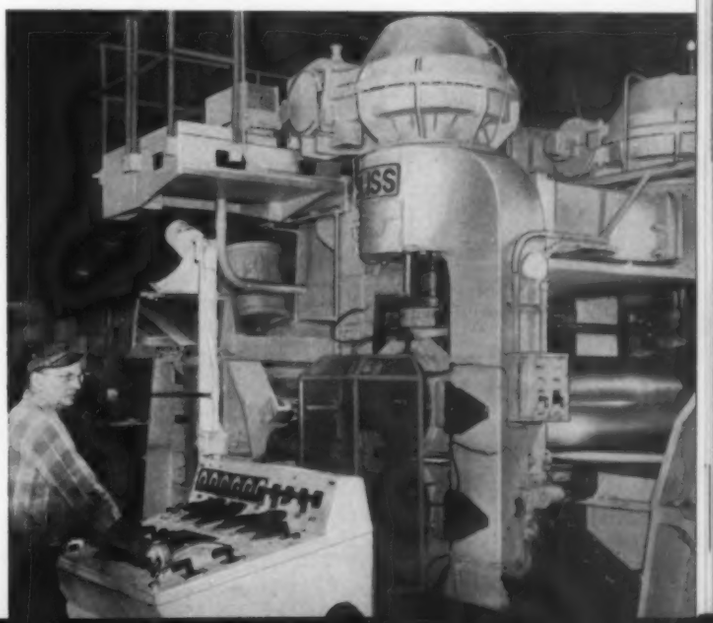


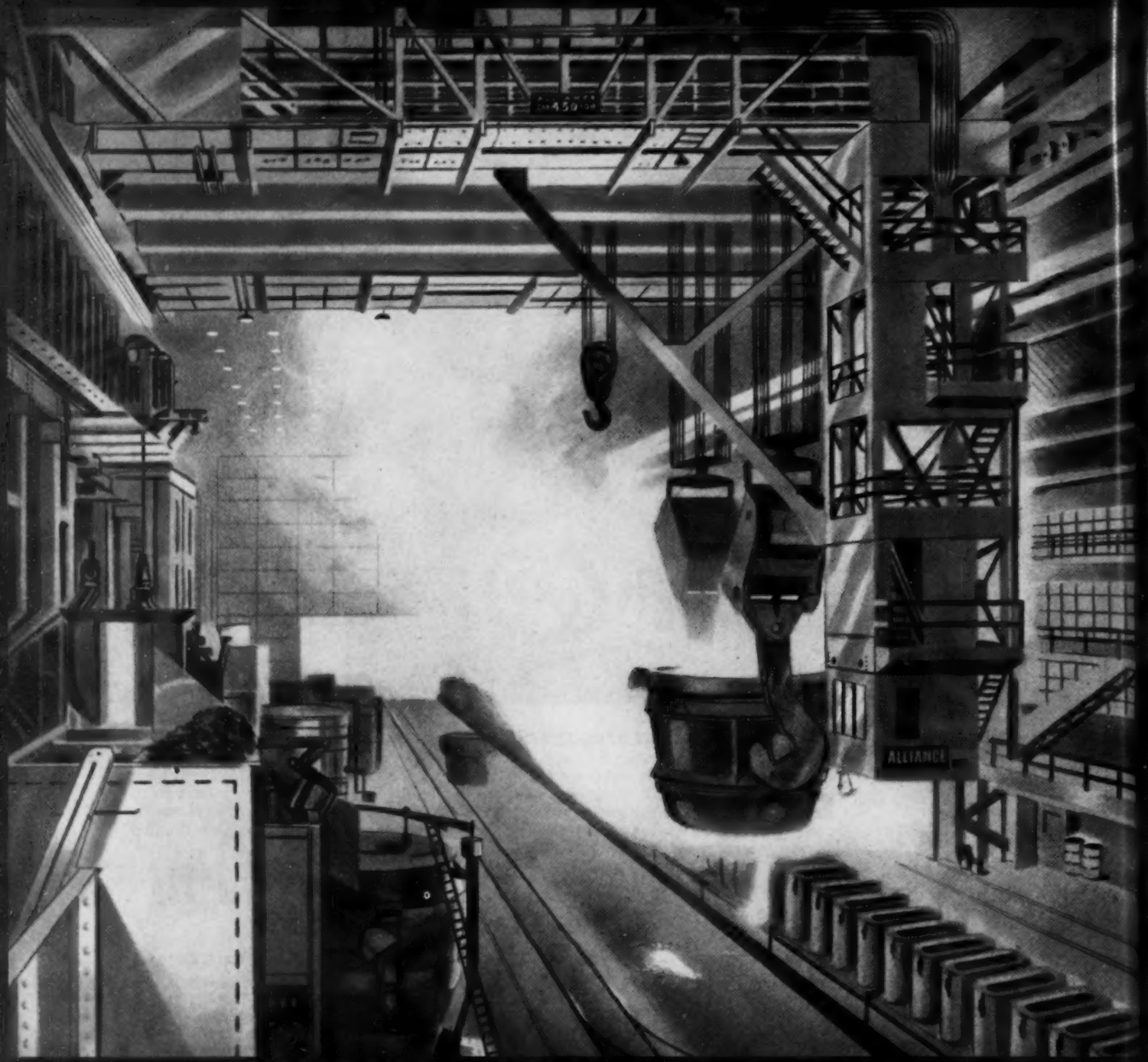
1 TEMPERS TIN PLATE AT 3700 FPM. This 19″ and 53″ x 48″ Bliss Two-Stand Tandem Mill tempers tin plate in gages from 0.007 in. to 0.015 in. to a width of 36 inches. (It can, however, roll up to 44-in. width maximum, if needed.) Motorized conveyors feed coils into and away from the mill, eliminating handling and minimizing stock damage. In line with latest design trends, all driven rolls are *individually motorized* (left) including cone payoff reel, auxiliary tension rolls and tension winder. This arrangement results in lower inertia factors for accelerating and decelerating, plus other advantages. On roll drives, special "thrust pedestal stand bearings" are provided to protect drive motors in roll changing.

2 A NEW DEVELOPMENT IN STEEL MILLS is this 32″ x 80″ Bliss Two-High Mill, an integral part of the pickling line at Fairless. In a use unique to the steel industry the mill gives the strip a light reduction, shapes it and pulverizes its tight oxide (formed with the rapid cooling which follows hot rolling), thereby making the material easier to pickle. The entire pickling operation is speeded and tonnage is boosted considerably.



3 IN THE SHEARING AND SLITTING LINE is this 32″ x 80″ Bliss Two-High Mill—where it tempers and flattens the strip prior to shearing. Representing the latest design in this type of mill, it has complete controls and a special DC motor drive to supply the necessary wide range of speeds. By using the mill in this way, U. S. Steel completely eliminated an extra handling operation, which is so important to its high quality-control standards.





450/75/20-ton 4-girder ladle crane with 69'-6" span. 2-motor, synchronized worm drive. Vibrationless under all operating conditions. Operator's cab air-conditioned.

400-ton capacity push-pull Stripper and Extractor Crane. 2.5-million-pounds pressure eliminates stickers. Overload rating of 1250 tons. One operator.

200/30-ton 4-girder double trolley hot metal ladle crane., 80' span.

BIG cranes for BIG steel

(FAIRLESS WORKS)

30-ton capacity, telescopic ram, low head room soaking pit crane. 106'-0" span. Tong range 12" min., 72" max.

The four cranes illustrated on these pages are the largest of their type in the world. They were created by teams of Alliance and U. S. Steel engineers for U. S. Steel's new Fairless Works.

Alliance cranes function in virtually every department in the mammoth Morrisville plant—day in and day out—safely, efficiently and economically . . . helping to establish new production records.

The techniques embodied in these giant cranes can be embodied in cranes designed for operation in your plant. When it's time to consider your crane requirements come to Alliance. We'll be glad to analyze your needs and work with you to effect the most efficient and economic solution of your problem.

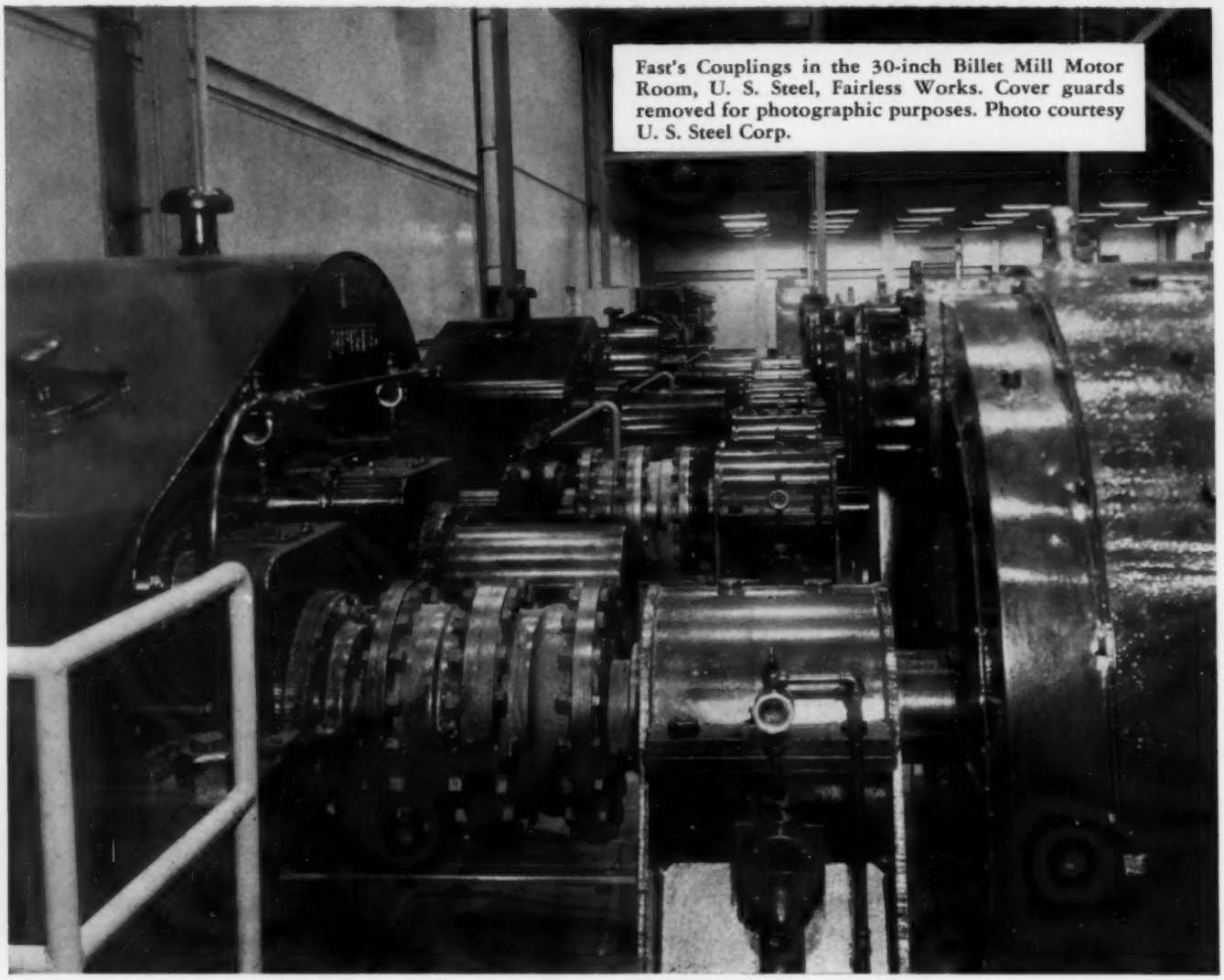
"Give Us the Runway and We'll Lift the World"

THE *Alliance* MACHINE COMPANY

Main Office, Alliance, Ohio — *Founded 1901*

LADLE CRANES • GANTRY CRANES • SOAKING PIT CRANES • STRIPPER CRANES
FORGING MANIPULATORS • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

World's Largest Builders of the World's Largest Cranes



Fast's Couplings in the 30-inch Billet Mill Motor Room, U. S. Steel, Fairless Works. Cover guards removed for photographic purposes. Photo courtesy U. S. Steel Corp.

U. S. Steel's Fairless Works equipped with Fast's Couplings

When U. S. Steel equipped its new Fairless Plant they selected Fast's Couplings for installation.

It's no wonder that U. S. Steel specified Fast's. Fast's Couplings have the approval of industry in general everywhere.

Industry finds that Fast's Couplings minimize down-time. Fast's, *the original gear type* couplings, give trouble-free performance. Save on maintenance. Save money (often thousands of dollars in production losses) because there is no down-time due to breakage or expensive replacement of perishable parts.

They also offer the lowest cost per year . . . usually outlast the equipment they connect. Many still in use after 30 years. Why? Because they are ruggedly constructed of the sturdiest, most practical materials . . . all steel in construction, unique in design.

35 years of experience in developing these materials and designs means our staff is well prepared to give you the most effective and cost-saving solutions to your coupling problems. Let Koppers help you. Just write, outlining your requirements. And mail the coupon below for additional general information.

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METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.

Engineered Products Sold with *Service*

THE ORIGINAL

FAST'S Couplings

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* **216 Scott St., Baltimore 3, Md.**

Gentlemen: Please send me a Free, Fast's Coupling Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

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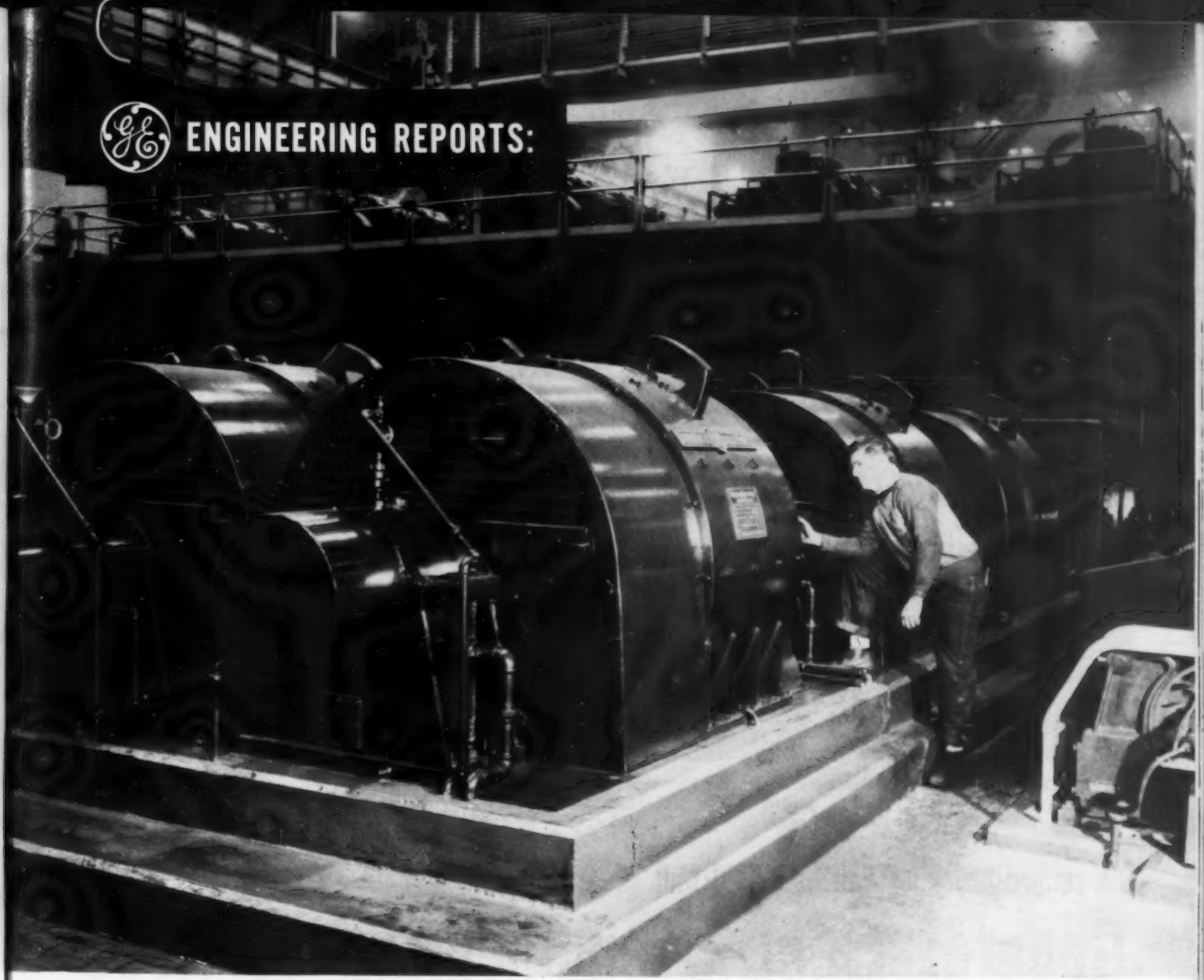
City.....Zone.....State.....



RECORD HORSEPOWER. G-E main drive system for world's fastest cold mill at Fairless has record total horsepower of 21,650. This triple-armature twin drive packs 6000 horsepower into No. 5 stand.

Drive-engineered by General Electric . . .

World's fastest cold mill rolls at 7000 fpm

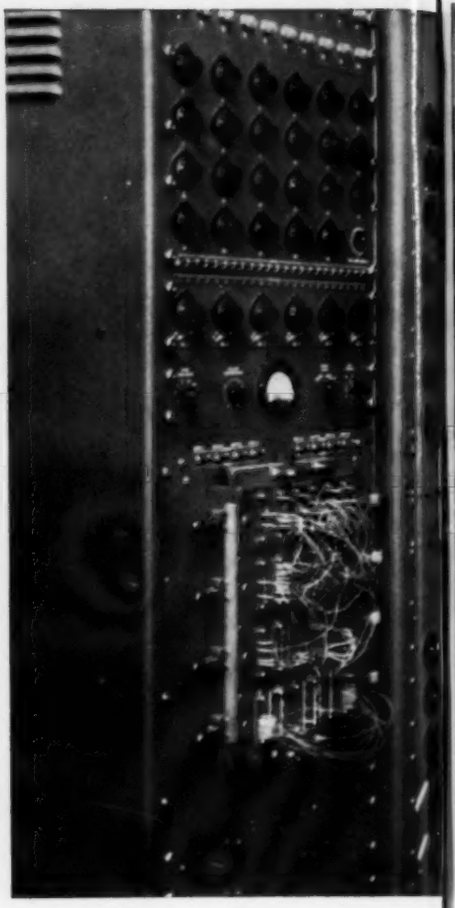
Showcase of the steel industry, the new Fairless Works of United States Steel at Fairless Hills, Pa., reflects the latest in drive engineering and equipment —much of it General Electric. Typical is this 5-stand tandem cold reduction mill, powered by a General Electric drive system.

Fastest in the world, this cold mill speeds at 7000 feet per minute—almost 80 miles per hour—delivering two tons of .009-inch-thick strip per minute. Acceleration from standstill to top speed takes only ten seconds. And the combined 21,650 horsepower of its main drives is also a record for this type of mill.

G-E designed individual-generator control gives the mill greater flexibility and simplicity of operation, plus a higher percentage of "on-gage" strip. G-E drive motors, specially designed to reduce stored energy to a minimum, permit acceleration and deceleration at the high rates required. And responsive auxiliary drive system helps assure accurate control of gage and shape of strip even at these high speeds.

See next page for design story ▶

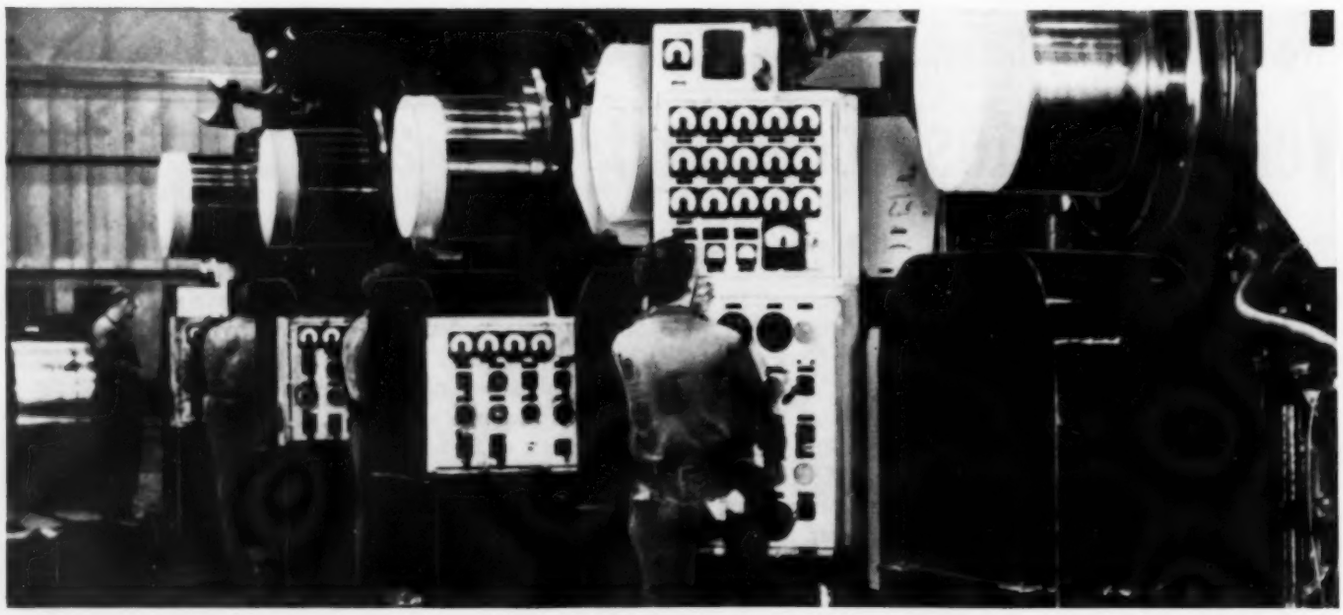
GENERAL ELECTRIC



APPLICATION ENGINEERING—On the job from early planning stages through start-up, G-E Application Engineers like W. E. Miller (left) helped design and install drive system. Here, he discusses 5-stand mill control with U.S. Steel engineers.

At record-breaking Fairless Cold Mill . . .

General Electric engineering services



PRODUCT ENGINEERING—One man has control of 5-stand mill from main control board at No. 2 stand. G-E Product Engineers designed special control equipment which continuously monitors performance, and perceives and corrects variations.

ANALYTICAL ENGINEERING—New circuitry for the 7000-fpm mill was developed using computers such as this electronic differential analyzer being operated by G-E Analytical Engineer F. S. Roth. Application Engineers C. C. Thomas and R. G. Beadle check results of a "run" of the mill just completed on the analyzer to eliminate problems before installation.

save planning time, speed start-up

FIELD ENGINEERING—Helping with mill's installation and start-up operations, G-E Field Engineers H. L. Peacock (left) and C. E. Batchelder test differential relays with a U.S. Steel engineer.

Key factor in the success of Fairless' cold reduction mill drive was the over-all system approach which co-ordinated the electric and process equipment. U.S. Steel and Mesta engineers, working with G-E engineers as a team, designed the 21,650-hp main drive system.

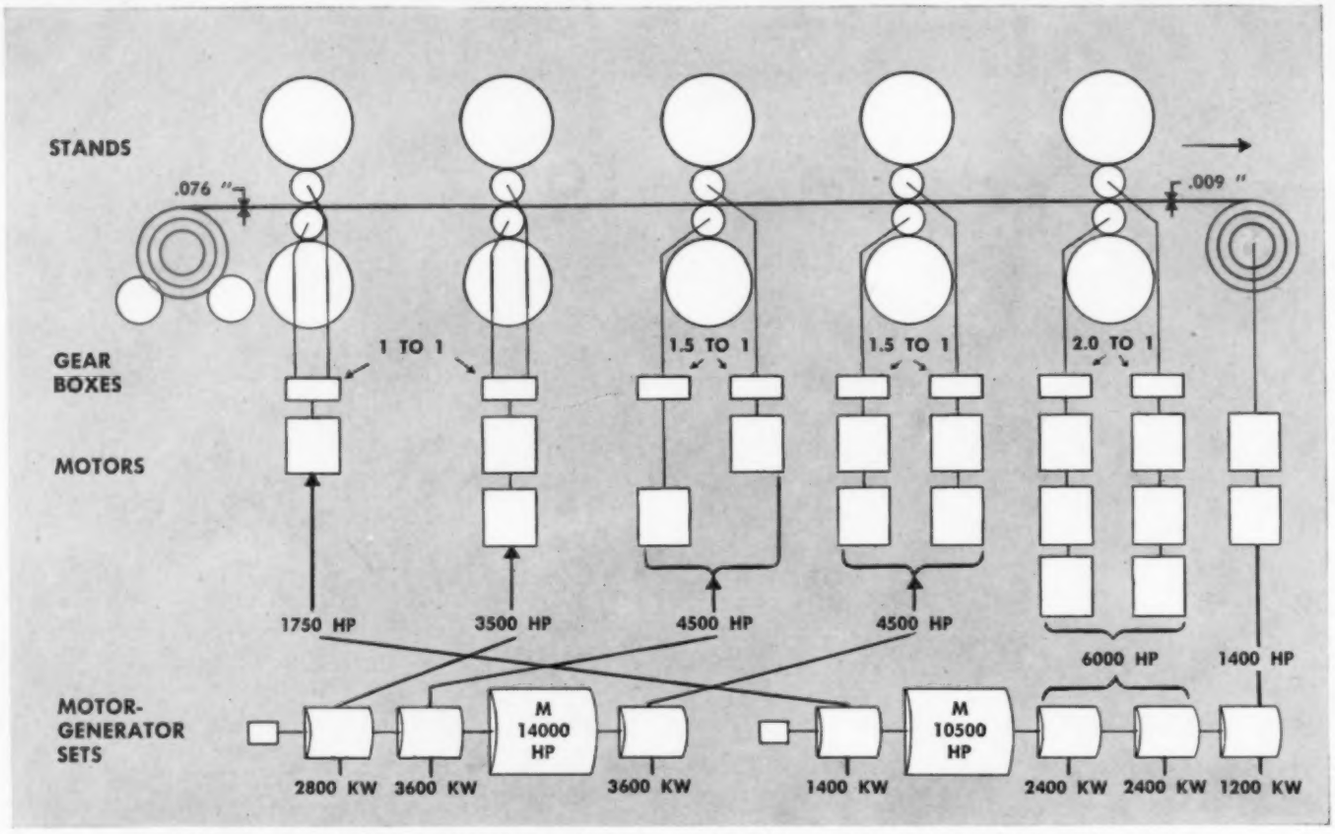
Backing them up were G-E engineers who "ran" the mill on electronic computers to eliminate problems before installation, designed new control and drive circuits, assured the right equipment arrived at the right time, and helped start up the mill.

Whatever *your* steel-mill electrical requirements, these and other G-E engineering services are available to help you achieve higher speeds for greater output, more accurate control of product quality, and lower unit costs to meet today's demands. Your local G-E Apparatus Sales representative will put them at your service. Contact him early in the planning stage. General Electric Company, Schenectady 5, N. Y.

See next page for engineering details ▶

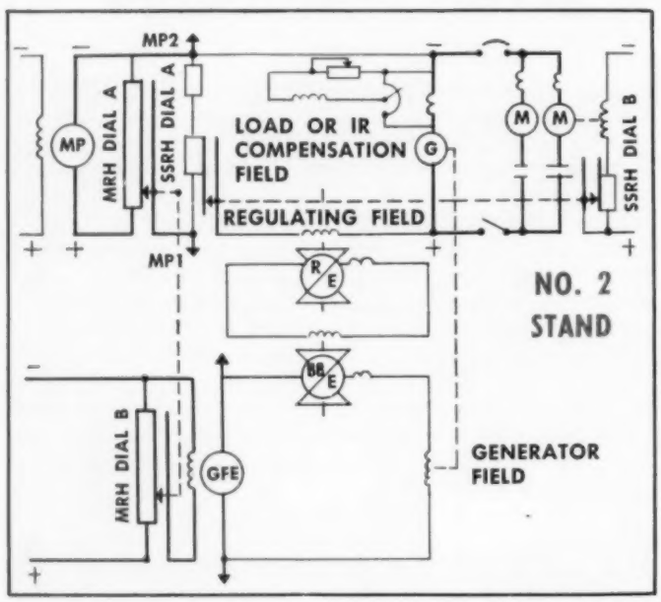
GENERAL ELECTRIC

Another example of G-E drive engineering at work!



17 MAIN DRIVE G-E MOTORS, RANGING FROM 700 TO 2250-HP, DRIVE 5-STAND TANDEM COLD REDUCTION MILL

G-E individual-generator control helps keep strip "on-gage" at Fairless Mill



How G-E individual-generator control works

In control circuit of No. 2 stand (left), mill master rheostat MRH determines voltage on master voltage control bus MP1 and MP2, which is the standard by which each generator's voltage is controlled. By raising or lowering voltage on this bus, voltage of all generators may be raised or lowered in proportion. Mill master rheostat also controls excitation on generator-field exciter GFE, which supplies all stand generators. In this way, regulating amplidynes RE and BBE on each stand can operate at low voltage levels ideal for fast regulator action.

Individual voltage adjustment on each generator is determined by stand master rheostat SSRH. Each stand-motor's speed is also controlled by adjustment of its shunt-field current by this same rheostat.

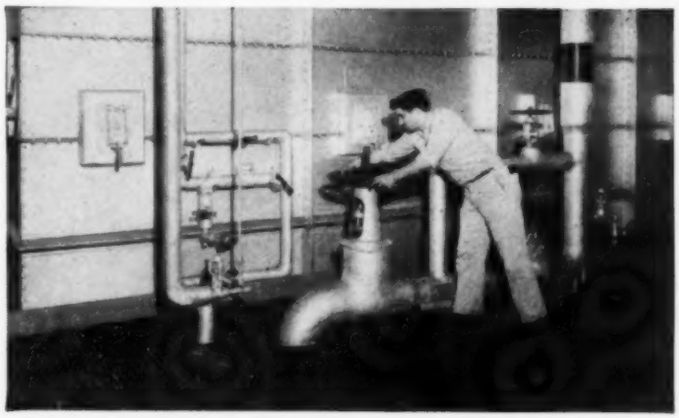
Load, or ohmic-drop compensation, is provided in the regulating system to insure the maximum amount of "on-gage" strip during acceleration, running, and deceleration of the mill.

To accelerate the mill to threading speed, then to running speed, and then back to threading speed, operator need only press respective buttons on conveniently located control cabinet. A full complement of indicating instruments is provided for operator to check speed, load, tension between stands, winding-reel tension, and gage during rolling operation.

659-102

GENERAL ELECTRIC

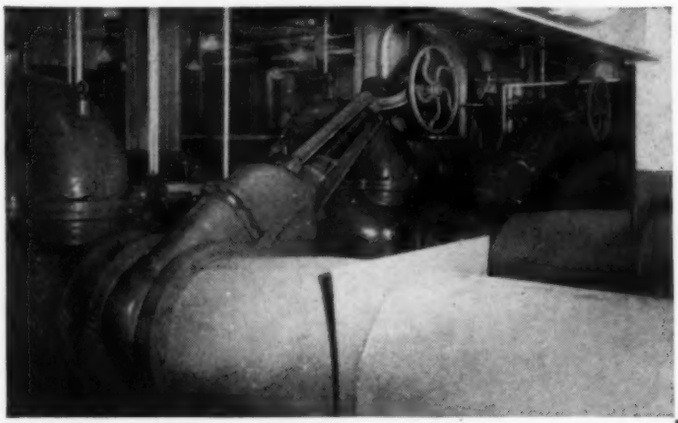
At Fairless Works, they Measure Service Piping by the Mile



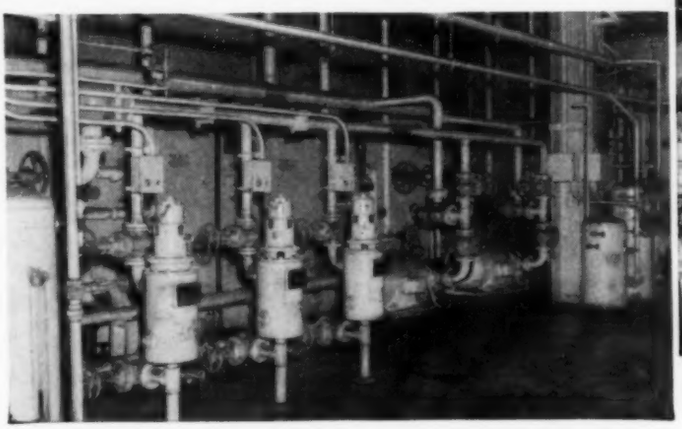
In the power plant, Crane Pressure-Seal and Lip-Seal valves handle high-pressure/high-temperature services.

You can see plainly the part that piping plays in Fairless Works' operation. For you name the fluid—water, steam, air, oil, gas, or acid —and most likely it's highly essential for power, processing, or general utility. Piping systems interweaving the Works run from 48-inch diameter down to ⅛-inch, and if laid end to end, could be measured by the mile.

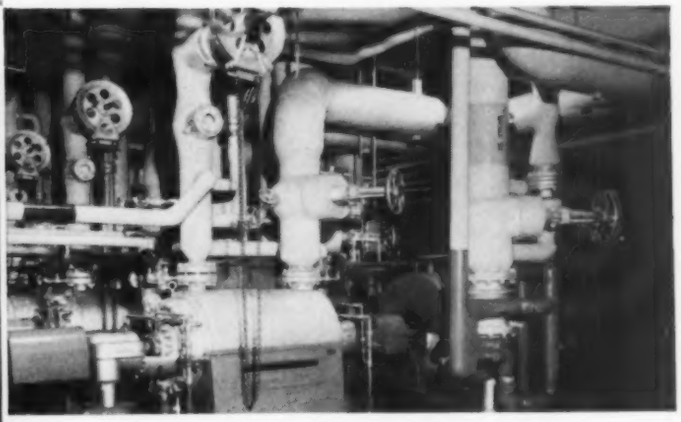
For safe and dependable control of fluids, Fairless Works' engineers and buyers rely heavily on Crane valves. In the giant lines as in the smallest, in severest services as in the mild, Crane quality is helping to hold piping maintenance costs to a minimum.



Crane iron body gate valves on large water intake lines.



In pits under the rolling mills, Crane steel valves by the hundreds operate the lubricating oil lines.



Crane Pressure-Seal and conventional steel gate and check valves in lines to feed water pumps to boilers.

THE BETTER QUALITY . . . BIGGER VALUE LINE . . . IN BRASS, IRON, STEEL

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

CONTINENTAL

40-INCH BLOOMING-SLABBING MILL

WITH AUXILIARY EQUIPMENT IN FAIRLESS WORKS

Continental designed and built this complete 40-inch Blooming-Slabbing Mill for United States Steel Corporation's new Fairless Works. Installed for intermediate blooming, it also has been employed in rolling slabs direct from ingots.

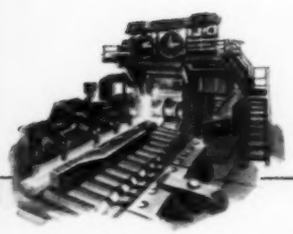
View of mill from Operator's Pulpit.

Continental Downcut Bloom and Slab Shear.

Continental High Speed Transfer delivering blooms to the mill.

★ Complete Rolling Mill Installations ★

ROLLS STEEL CASTINGS WELDMENTS



Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

CHICAGO • PITTSBURGH

CONTINENTAL
Foundry & Machine
Company

More than 4,000

P-G STEEL GRID RESISTORS

in FAIRLESS WORKS

are used to control Cranes and Ore Bridges

Designed to fit your present resistor space

STEEL GRID RESISTORS
consistently prove their value in
STEEL MILL SERVICE

Write for Bulletin No. 500

By use of those durable raw materials . . . steel and mica, and the P-G exclusive features of design, these Steel Grid Resistors have the "built-in quality" to overcome factors which often cause resistor failures. Vibration, moisture laden or corrosive atmospheres have little effect on continuity of service. Try Post-Glover Resistors for heavy duty applications where resistors are subject to severe service . . . continuous "Trouble-Free" performance is assured.

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

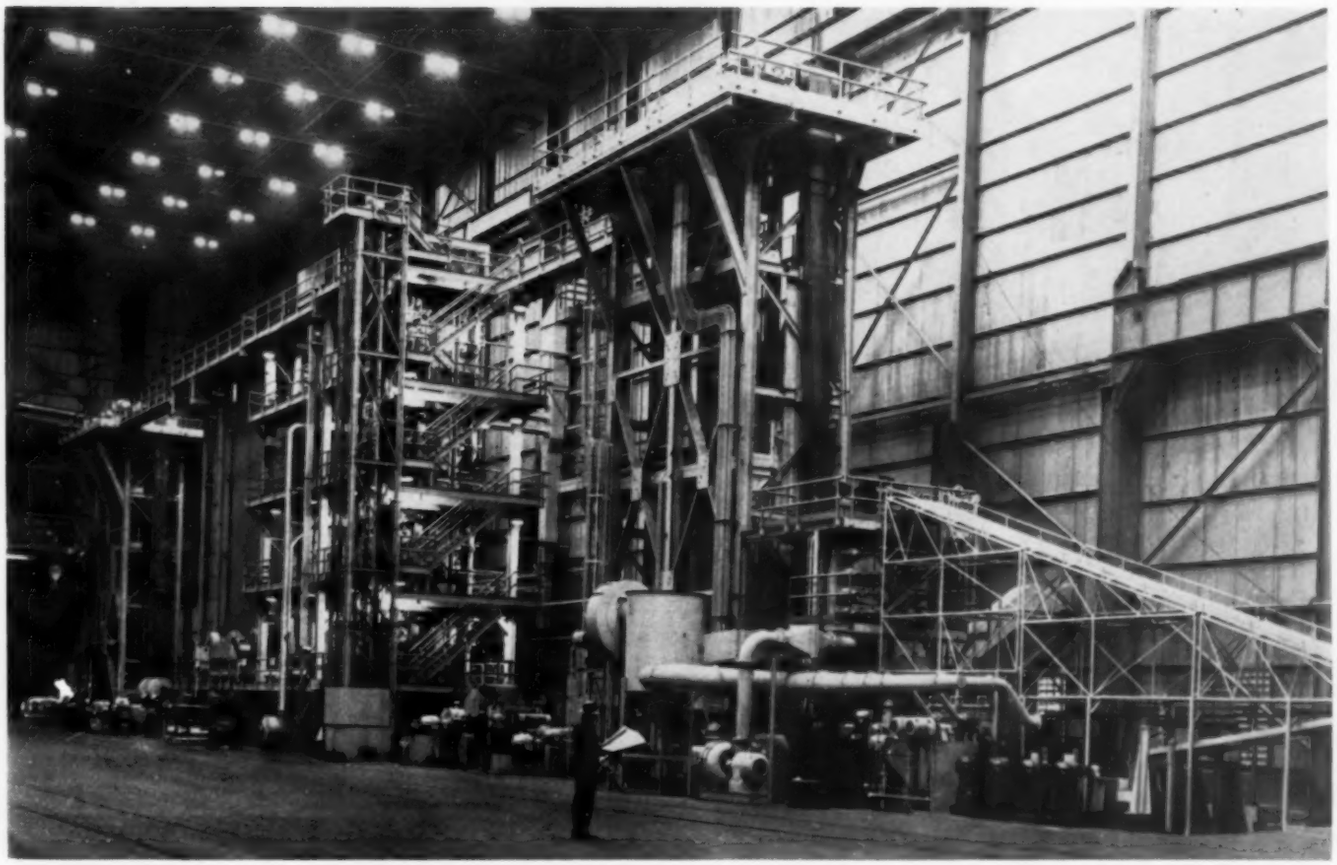
• ESTABLISHED 1897 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

THE CONTINUOUS ANNEALING LINE AT FAIRLESS WORKS

INSTALLATION BY

J. M. FOSTER CO. INC.



OTHER FACILITIES AT FAIRLESS WORKS INSTALLED BY J. M. FOSTER CO., INC.

Raw Coil Conveyors
Continuous Pickling Line
Temper Mills
Side Trim and Recoil Lines
Hot Dip Tin Lines and Auxiliary Equipment
Electrolytic Tinning Line
Roller Levelers
Inspection Lines
Electrolytic Cleaning Line
Heavy and Light Gage and Combination Shear Lines
Stretcher-levelers
Roll and Machine Shops — Complete
Tractor and Battery Shops — Complete
Air Compressors
Auxiliaries for Sheet and Tin Mill Processing Facilities
Bar Mill — Complete
Turbo-generators and Turbo-blowers
Gas Conditioning Facilities
Scrap Press and Auxiliaries
Oxygen Generating Stations
Sanitary Booster Pumping Stations
Shot Blasting Equipment and Auxiliaries

J. M. FOSTER CO. INC.

Erectors of Industrial Rolling Mills and Processing Equipment - Foundations - Piping - Electrical

5711 West Fifth Avenue
P. O. Box 622
GARY, INDIANA

Phone Gary 3-8504 **Chicago — Regent 4-5736**

5 Morgan Ejectors

at The Fairless Works

OF THE UNITED STATES STEEL CORPORATION

Four Morgan Ejectors are on the Rust Slab Heating Furnaces on the Hot Strip Mill.

One, shown here, is on the 10′ Morgan Continuous Bar Mill Billet Heating Furnace. This Rust Furnace has a greater capacity in tons per hour than any billet furnace previously built.

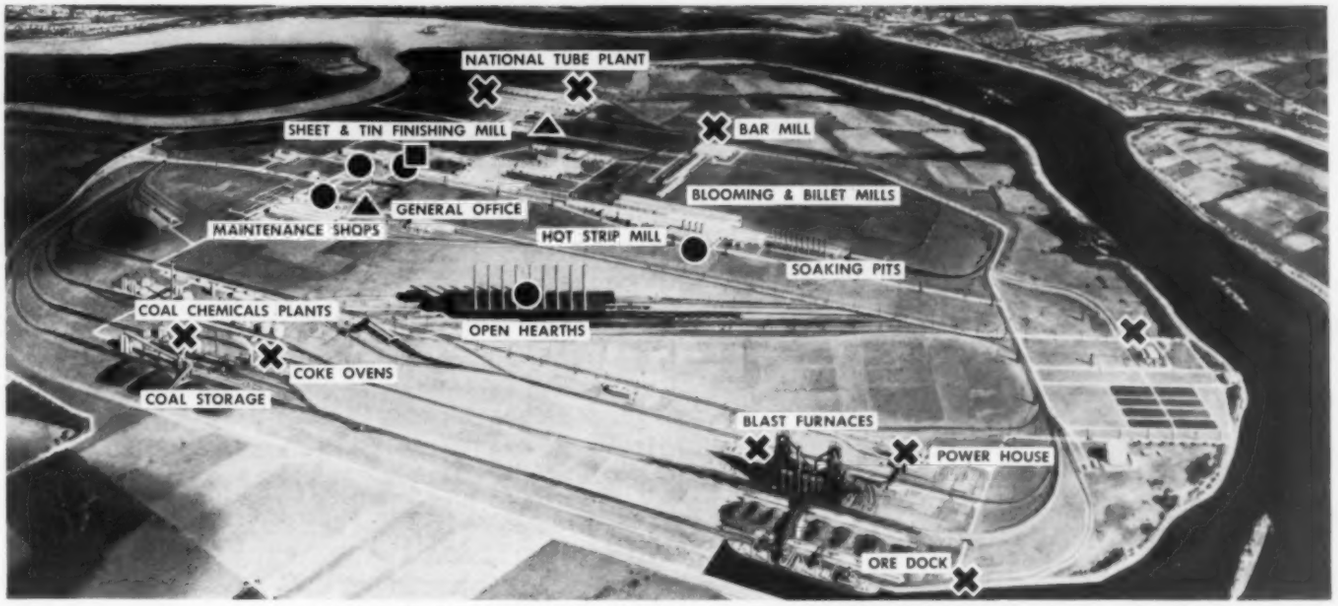
We like to think Morgan Ejectors help.

CCC-44G

MORGAN CONSTRUCTION CO.

WORCESTER, MASSACHUSETTS

ROLLING MILLS • MORGOIL BEARINGS • REGENERATIVE FURNACE CONTROL • EJECTORS • WIRE MILLS • GAS PRODUCERS



Modern food service for United States Steel's Fairless Works is provided by four self-contained canteens, four mobile units and two dining rooms.

The Steel Industry's Most Complete Food Service Installation!

● Hot foods served from four motorized canteens, as well as over an adjacent canteen counter, are prepared in this well equipped, modern kitchen. Others, equally modern, are somewhat smaller.

● Fast, cheerful service speeds traffic at this typical canteen alongside the Sheet & Tin Mills. Each canteen has its own kitchen.

✖ Hot nourishing food is served at remote points on a definite schedule. Four motor trucks with plug-in electrical equipment, stainless steel hot tables and cold boxes, carry food to nine service locations.

From ground breaking to full operation, Fairless Works employees have been furnished with continuous food service. The in-plant feeding is engineered to provide the latest in efficient, 'round-the-clock service in this efficient, modern mill. Factory Stores, with its extensive experience and large staff of specialists, considers this the most complete installation made during its 35 years in food service management.

Factory Stores

CLEVELAND 3, OHIO

Specialists in Food Service Management
Serving the Steel Industry Since 1919

▲ Highly efficient food service facilities do double duty on special occasions.

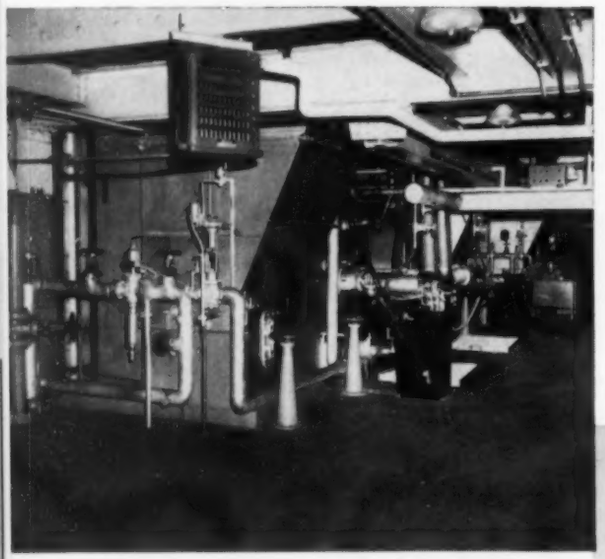
STEAM *helps make* STEEL

The United States Steel Corporation has purchased twenty-one steam generating units from Riley in the past fourteen years. Among these are the three steam generating units installed at Fairless Works.

These three 300,000 lbs./hr. units were designed for blast furnace gas fuel primarily, but can also develop full capacity on coke oven gas or liquid fuel.

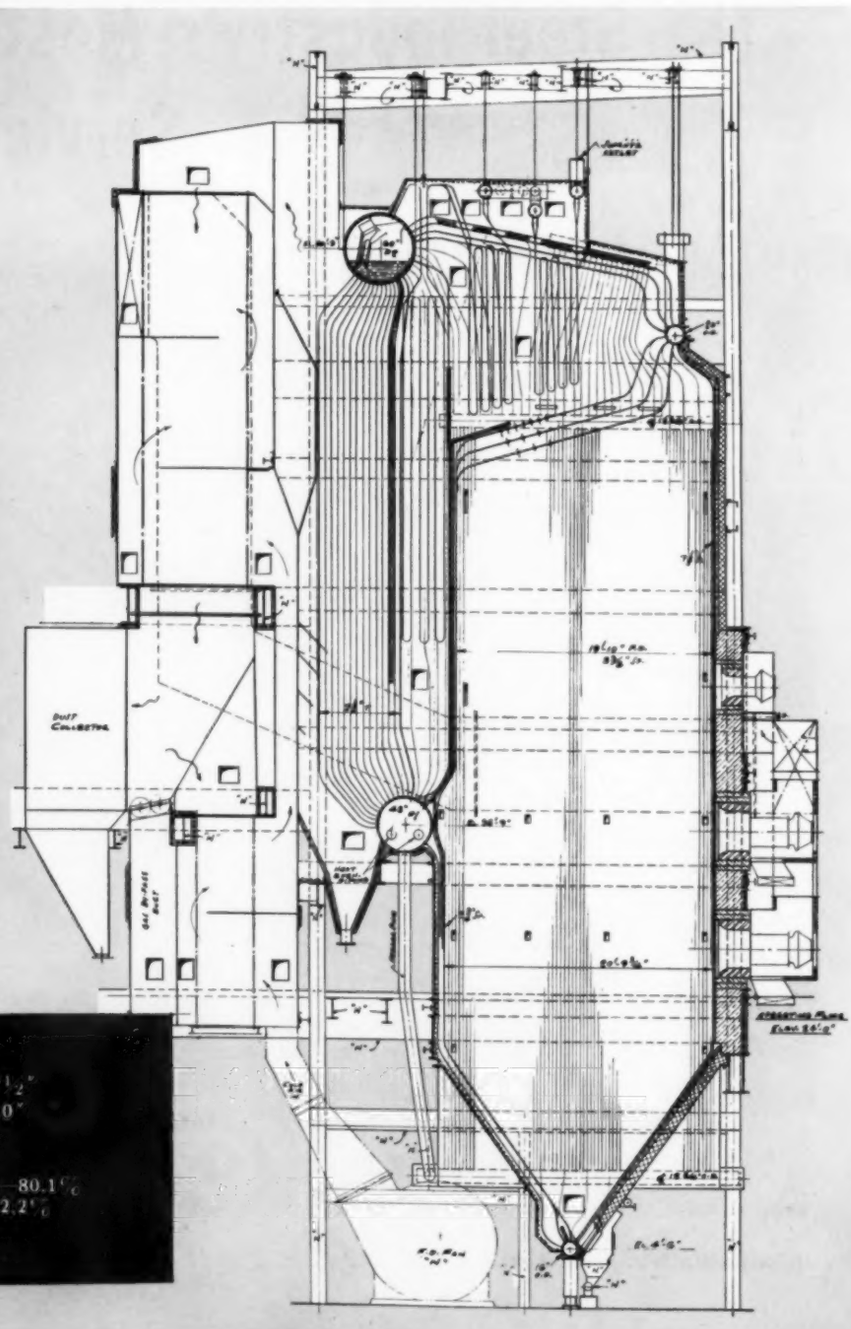
The desired steam temperature control range when firing blast furnace gas is obtained by the medium of a submerged heat exchanger in the lower boiler drum. Each unit is designed for future conversion to pulverized coal with Riley's exclusive single header hopper bottom furnace.

Other Riley units are operating at U. S. Steel plants in Braddock, Clairton, and Rankin, Pa., at South Chicago, Ill., and Gary, Ind. Three units are presently being installed at Johnstown, Pa.



Firing Aisle—showing controls for two of the three 300,000 lbs./hr. boilers at Fairless Works.

Riley Single Header Hopper Bottom construction reduces over-all height of unit and eliminates cost of separate hoppers.

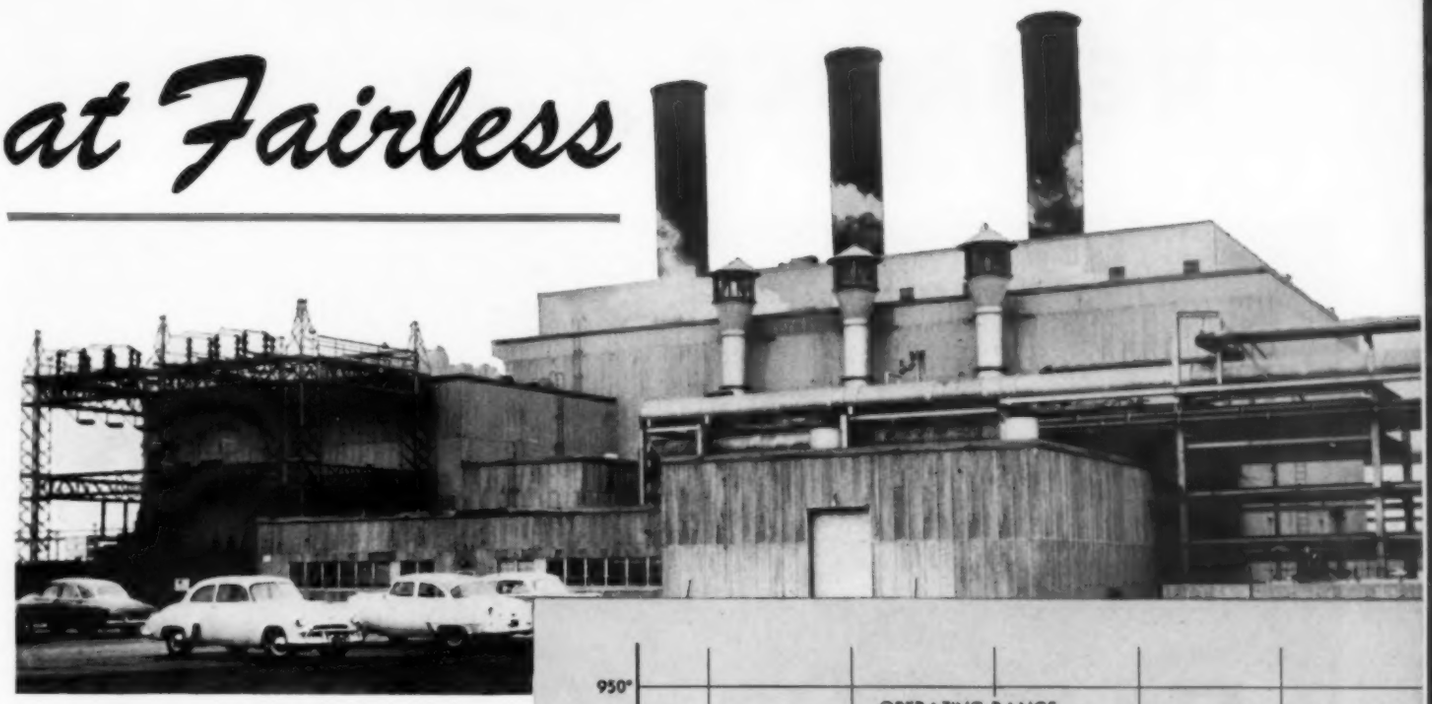


ENGINEERING DATA

Capacity—300,000 lbs. hr.
Design Pressure—885 psig.
Steam Temperature—900°F.
Heat Release per cu. ft. of furnace volume—18,300
Furnace Volume—26,570 cu. ft.
Furnace Width—25'7½"
Furnace Depth—19'10"
Furnace Height—57'
Efficiency
Blast Furnace Gas—80.1%
Coke Oven Gas—82.2%
Oil—86.4%

GIBBS & HILL—*Consulting Engineers*

at Fairless

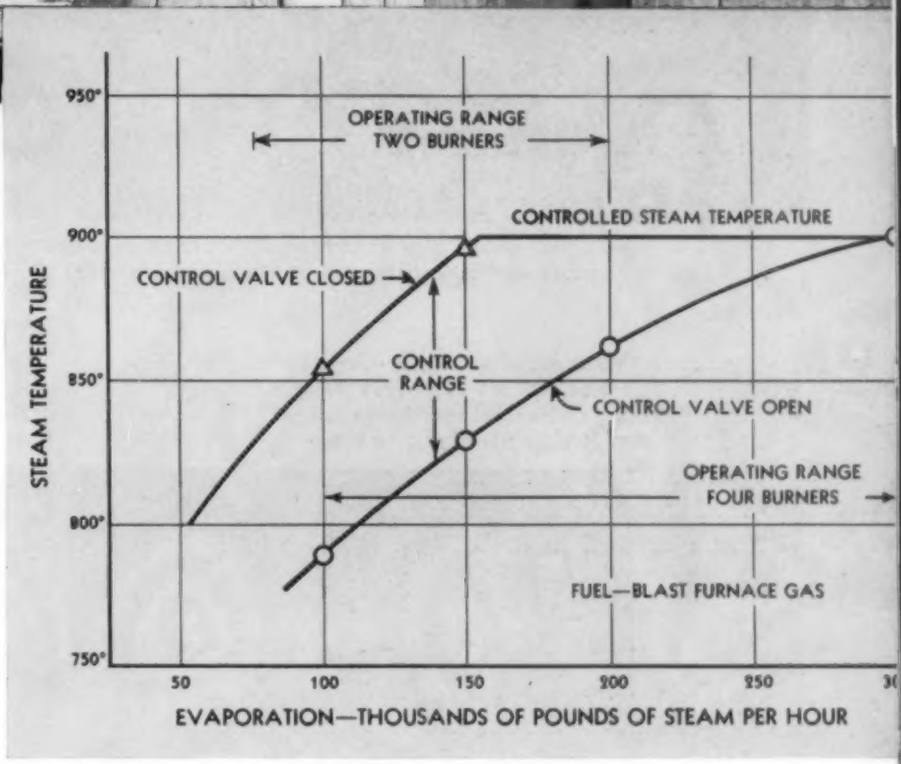


Boilers feature Constant Steam Temperatures Down to Half Load . . .

2 to 1 Control Range

Graph shows the wide range of temperature control obtained on each of the three Riley units when firing with blast furnace gas burners.

GIBBS & HILL—*Consulting Engineers*



A few other users of Riley units featuring Riley Single Header Hopper Bottom Furnaces

Whippany Paper Board Co.
Carbide & Carbon Chemicals Corp.
Colorado Fuel & Iron Corp.
Celanese Corp. of America
Monsanto Chemical Co.
Continental Can Co.

Hooker Electrochemical Co.
U. S. Rubber Co.
Western Electric Co.
Esso Standard Oil Co.
Swift & Company
Bird & Son, Inc.

Allis Chalmers Mfg. Co.
North American Aviation, Inc.
Calumet & Hecla Consolidated
American Viscose Corp.
Syracuse University
Great Lakes Steel Corp.

TRADE MARK Rx REGISTERED

RILEY
STOKER CORPORATION

WORCESTER, MASS.
Boston, New York, Philadelphia, Buffalo, Washington, Pittsburgh, Cleveland, Detroit, Chicago, Cincinnati, Charlotte, New Orleans, Atlanta, St. Louis, Kansas City, St. Paul, Tulsa, Houston, Denver, Salt Lake City, Los Angeles, San Francisco, Portland, Seattle

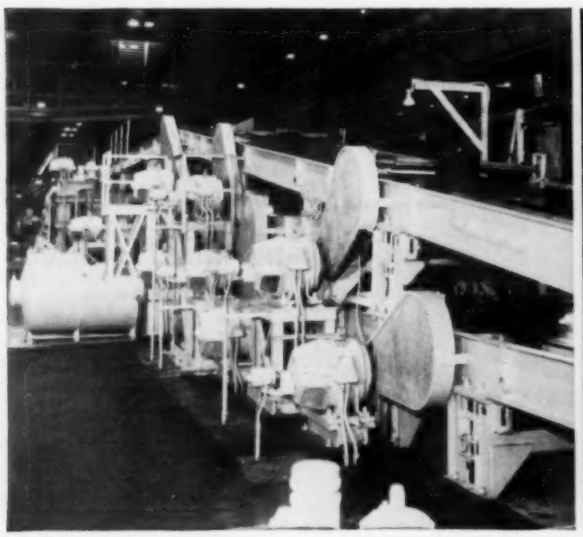
COMPLETE STEAM GENERATING UNITS

BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS • ECONOMIZERS
WATER-COOLED FURNACES • STEEL-CLAD INSULATED SETTINGS • AIR HEATERS

RELIANCE *Engineered*

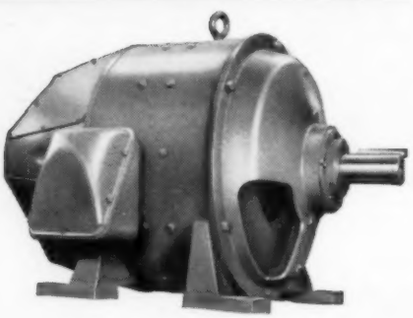
Entry end of 80″ Side Trimming and Shearing Line showing the rugged Reliance Motors for uncoiler and side trimmer . . . Shear and classifier drives can be seen in the background

View of 56″ Side Trimming and Shearing Line Classifiers featuring individual speed regulation of Reliance flight drive motors.



Drive side of the entry end of the Electrolytic Tinning Line as viewed from the drag bridle. Reliance Type "T" Heavy Duty Motors provide rugged dependability.

MOTORS *Applied Engineering* **CONTROLS**



Processing Line Drives

Speed Production

AT FAIRLESS WORKS

At the Fairless Works, Reliance Engineered Drives are the nerve center of important processing lines. Skillful application engineering has taken full advantage of the accuracy and rugged dependability these motors and controls have to offer.

Reliance Engineered Drives provide positive, precise control of production-line speeds to meet the needs of a wide variety of gauges and widths of materials being processed.

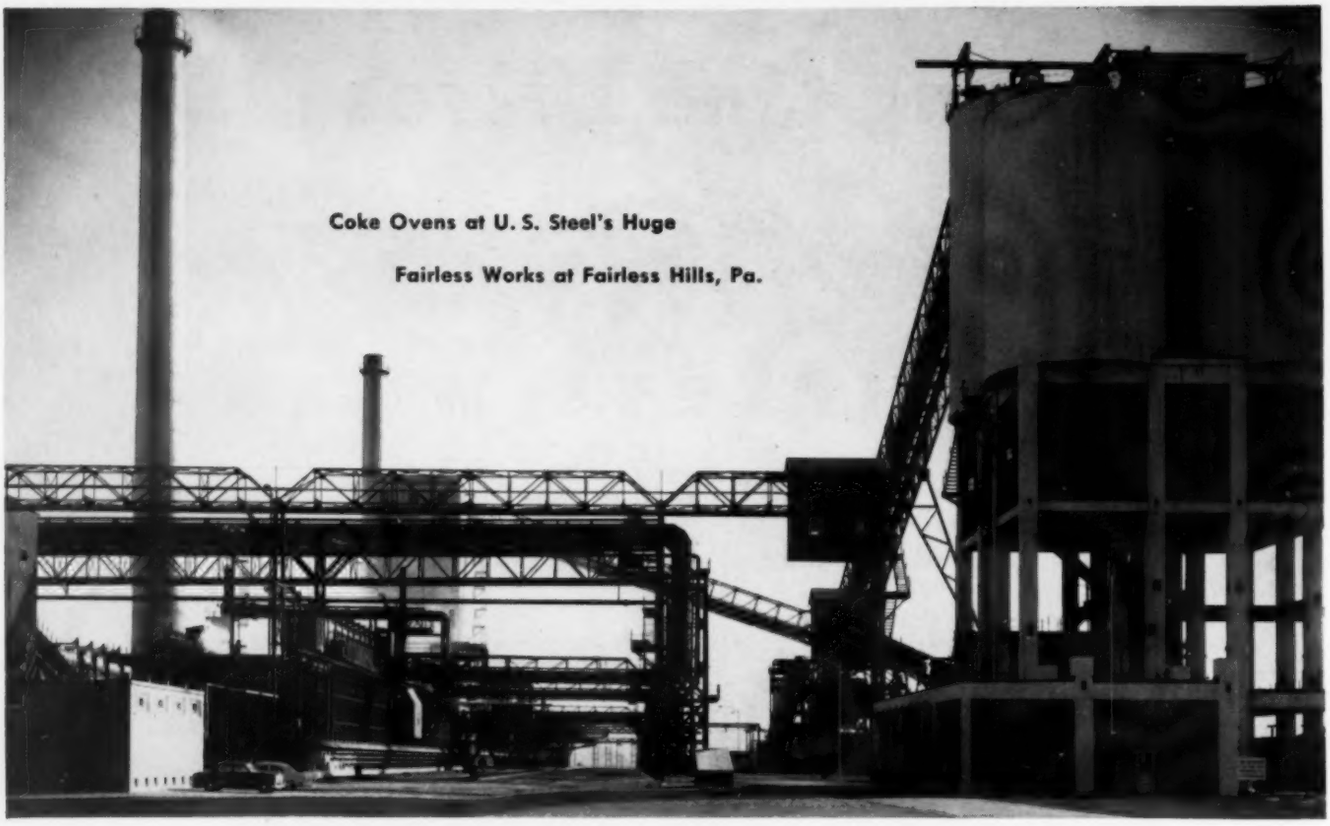
Users or builders of machinery can obtain better performance with specially-engineered drives. For facts and details, call your nearest Reliance Sales Office. We're ready to place nearly a half-century of experience at your disposal. A-1476

Drive side of the delivery end of 80″ Pickle Line. It consists of upcoiler, tension reel, bridle and shear pinch roll.

Entry end of 40″ Side Trimming and Shearing Line is shown here. The pay-off drive can be seen in the foreground with a battery of Reliance classifier drive motors in the upper background.

RELIANCE ELECTRIC AND ENGINEERING CO.

1084 Ivanhoe Road, Cleveland 10, Ohio • *Sales Offices in Principal Cities*



Coke Ovens at U. S. Steel's Huge Fairless Works at Fairless Hills, Pa.

Many proven Garlock products selected for U. S. Steel's Fairless Works

Garlock CHEVRON* Packing used on roll balance cylinders of hot and cold mills

Spool-type Rubber Expansion Joint used on industrial waste lines

Garlock LATTICE BRAID* Packing used for many general applications

Model 64 KLOZURE* Oil Seal used on hot and cold rolling mills

We are indeed proud that U. S. Steel chose Garlock packings, gaskets, mechanical seals, oil seals, and expansion joints for so many important installations in their great new plant. It is a real tribute to the reputation Garlock products have earned for long, trouble-free service under the toughest service conditions.

Let us show you how Garlock can help you to reduce downtime and cut maintenance costs. Just contact the Garlock representative in the sales office nearest you.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

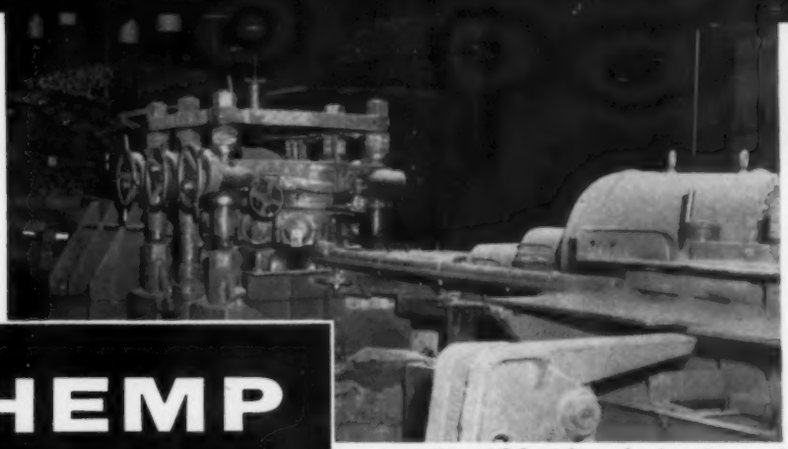
Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo Chicago • Cincinnati • Cleveland • Denver • Detroit • Houston • Los Angeles New Orleans • New York City • Palmyra (N. Y.) • Philadelphia • Pittsburgh Portland (Oregon) • Salt Lake City • San Francisco • St. Louis • Seattle Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

*Registered Trademark

GARLOCK

PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS, RUBBER EXPANSION JOINTS



Mack-Hemp AO Straightener has been in operation for six months, working 15 turns a week, taking out bends and hooks from ½" to 2" continuous butt-weld pipe in the National Tube Division of Fairless Works.

MACK-HEMP

salutes United States Steel on achieving another victory for private enterprise...the new Fairless Works

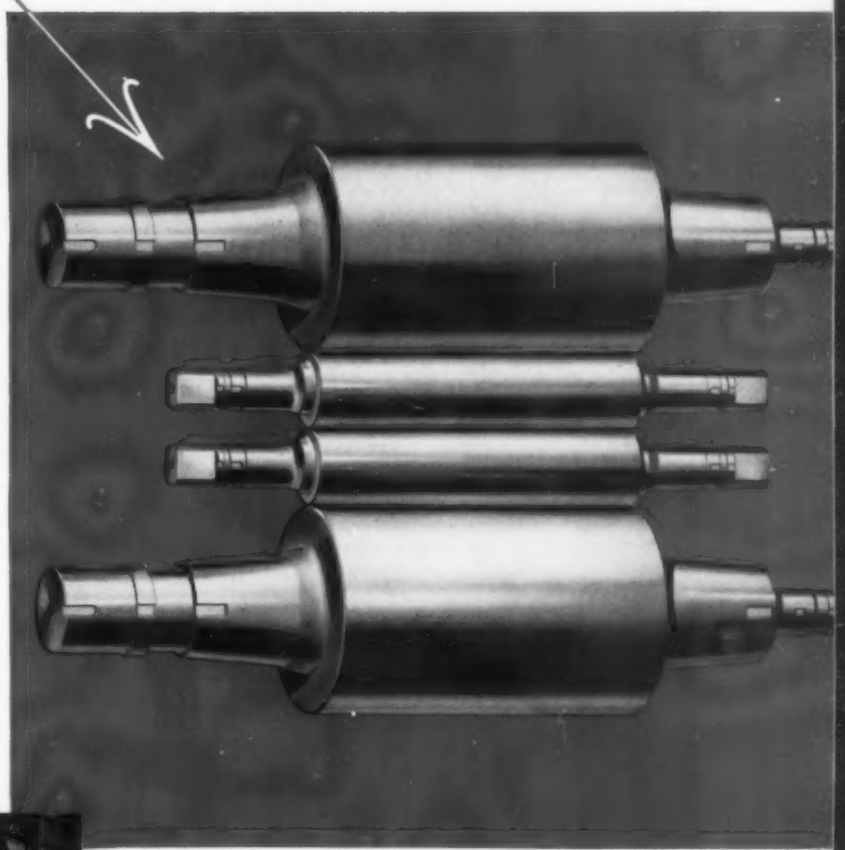
Mack-Hemp is proud to be partners in progress with United States Steel by playing an active part in the dramatic development and operation of the most completely modern steel mill in the world.

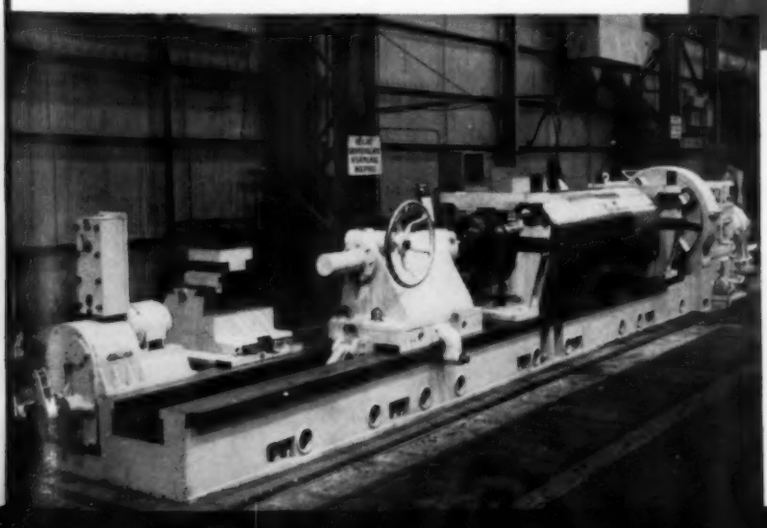
Dependable Mack-Hemp Rolls and machine tools are on the job in the modern, new Fairless Works of United States Steel at Fairless Hills, Pa.

Mack-Hemp Rolls are top performers in leading rolling mills everywhere. Rolls with the Striped Red Wabbler have helped set production records for over a century and a half—and they're still setting standards throughout the roll-making industry.

Mack-Hemp Striped Red Wabbler Rolls are backed up by years of roll-making experience and engineering know-how gained through close cooperation with rolling mill operators. Result? Increased production and increased efficiency wherever there's a tough rolling mill assignment.

Investigate the service records of Mack-Hemp Striped Red Wabbler Rolls. It's just good sense to put Mack-Hemp Rolls to work on your tough rolling mill requirements. Remember too, it *pays* to keep an eye on everything new at Mack-Hemp.





MACKINTOSH-HEMPHILL COMPANY

Makers of the Rolls with the Striped Red Wabblers

PITTSBURGH AND MIDLAND, PA.

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: all types of cast mill rolls . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . Mackintosh-Hemphill rotary straighteners—electronically controlled contouring lathes—screw feed roll turning lathes—heavy duty engine lathes . . . shears . . . end-thrust bearings . . . steel and special alloy castings . . . reversing hot strip mills . . . Y-type cold strip mills

Mack-Hemp Screw Feed Roll Turning Lathe has been operating for a year in the roll shop serving all the hot rolling mills at Fairless Works. It is used for roll dressing back-up rolls and work rolls for the strip mills.

Designed and Built by

YOUNGSTOWN WELDING & ENGINEERING CO.

For U. S. STEEL'S FAIRLESS WORKS

Three 15-Ton WELDCO MECHANICAL TUBE PICKLERS, like the one shown above, assure fast, efficient, low-cost pickling at the new Fairless Works. If **you** want uniform pickling, better finish, and big savings in manpower and maintenance, investigate WELDCO's complete line of Mechanical Picklers—for Bars, Tubing, Coils and Sheets.

Other WELDCO Pickling Products include:

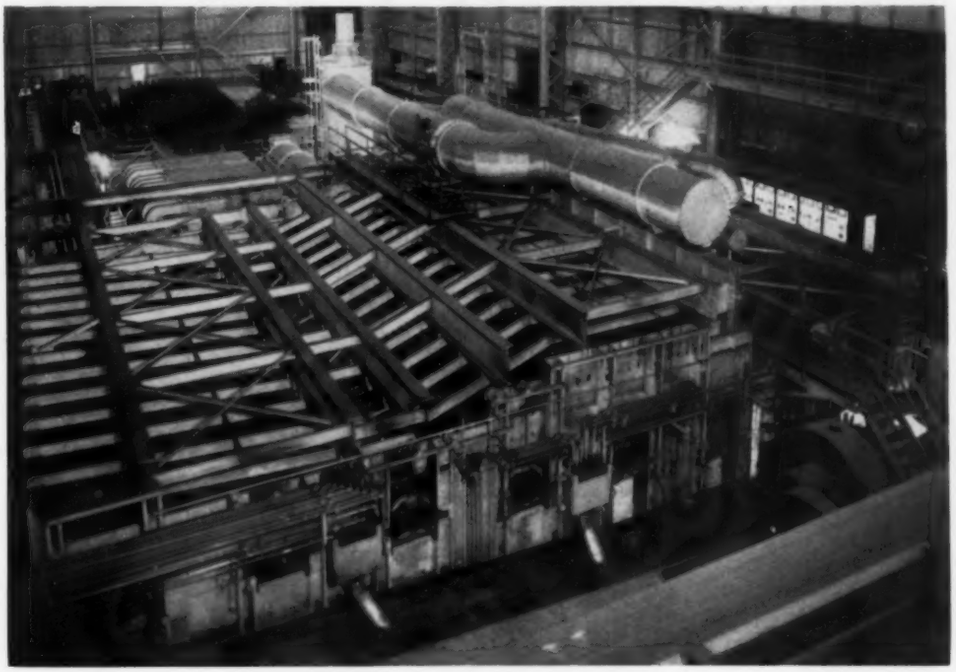
Hooks, Crates, Baskets, Racks, Chain, Steam Jets, and Accessories.

WELDCO

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3762 OAKWOOD AVE. YOUNGSTOWN 9, OHIO

THE INTERLOCKING ARCH, NOSE, AND SIDEWALL



All red letter items are serving "U. S. STEEL."

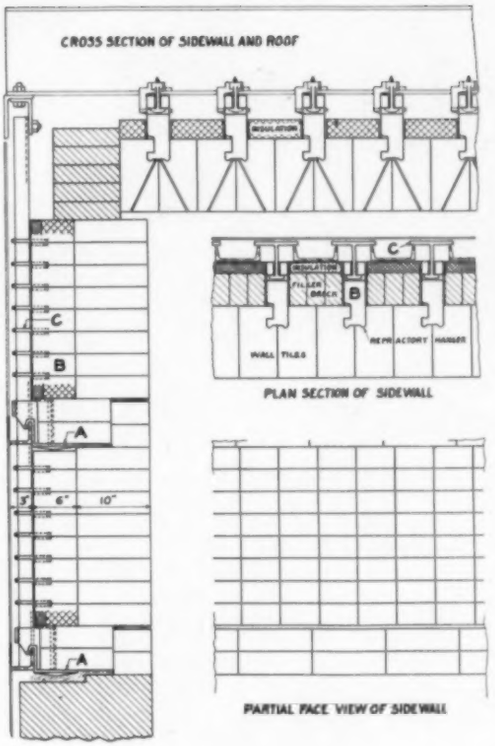
← Photo to left shows the Rust Furnace Co., Triple Fired, 43'-0" Wide, Bar Mill Furnace in use at U. S. Steel's FAIRLESS WORKS., Fairless Hills, Pa.

This furnace is equipped with the SIMPLEX INTERLOCKING SUSPENDED ROOF, SMALL RADIUS NOSE, and SECTIONALIZED SUSPENDED SIDEWALLS.

REFRACTORY HANGER ARCH

Line drawing at right shows general design and arrangement of the REFRACTORY HANGER type roof and SECTIONALLY SUSPENDED SIDEWALLS installed on the Bar Mill Furnace at FAIRLESS WORKS. The refractory hanger design of the suspended roof provides ample space for insulation and for cooling metal hanger castings.

For Better Furnace Efficiency, Economy and Durability let FRAZIER SIMPLEX Engineer and Furnish your suspended arch requirements.

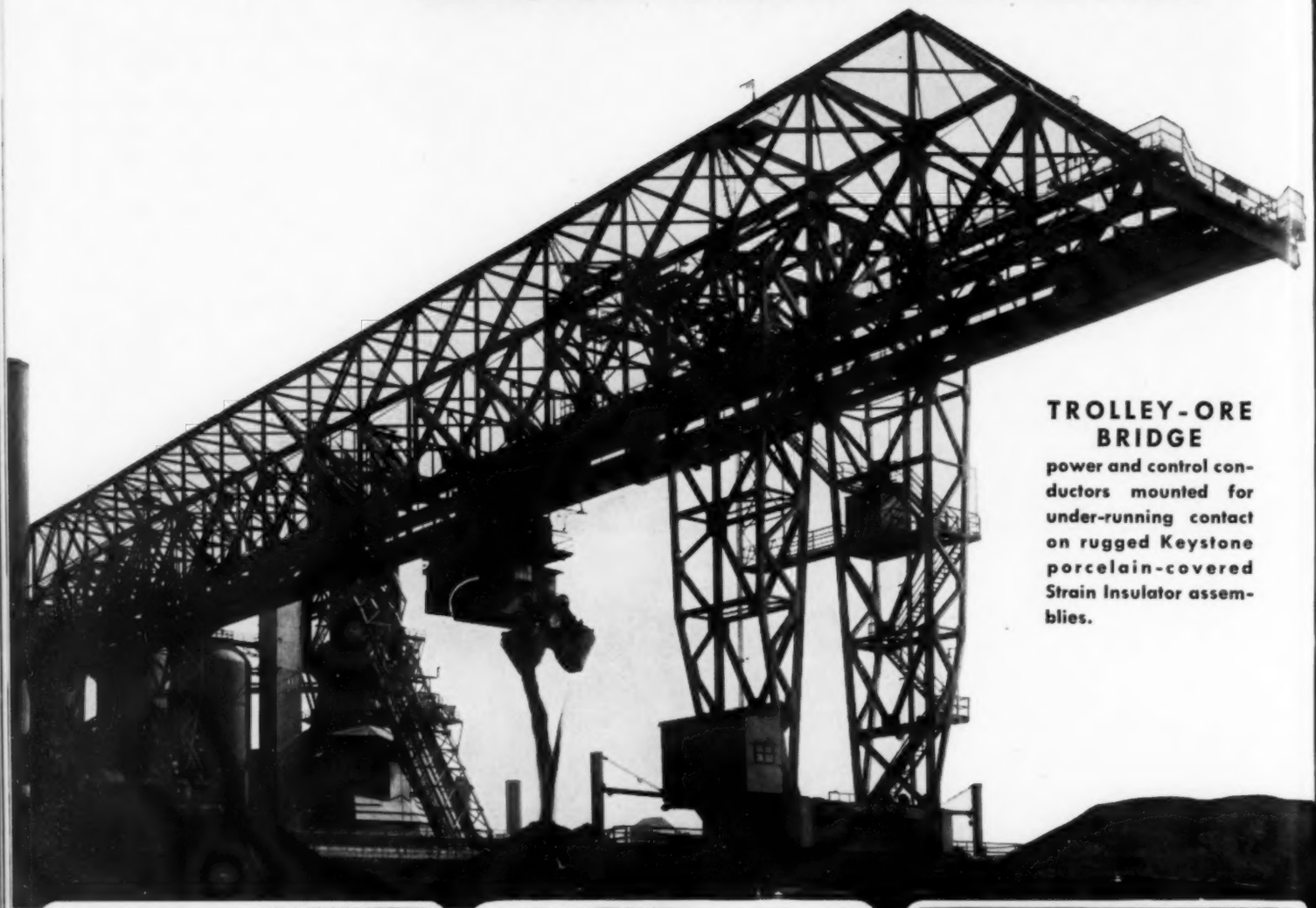


Interlocking Arch Department, L. S. Longenecker, Mgr.

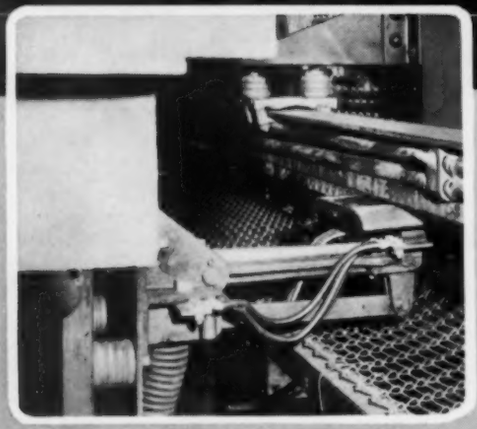
FRAZIER-SIMPLEX, INC.

436 EAST BEAU STREET • WASHINGTON, PENNA. U.S.A.

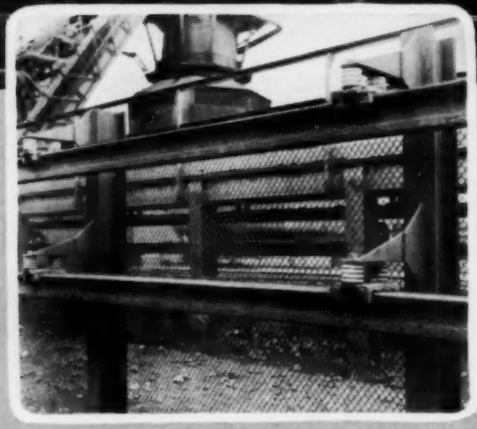
World's Newest Steel Mill Selects



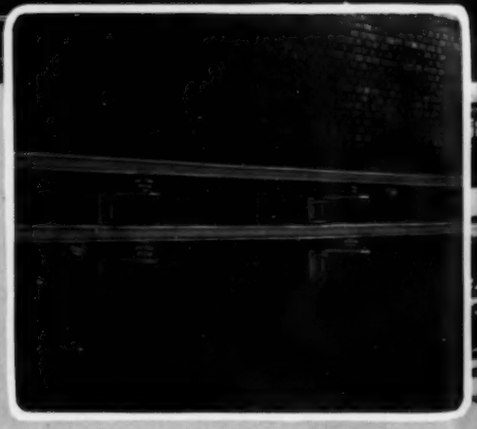
TROLLEY-ORE BRIDGE
power and control conductors mounted for under-running contact on rugged Keystone porcelain-covered Strain Insulator assemblies.



RUNWAY-ORE UNLOADER
Keystone Type PS Collector heavily constructed for severe service. Both contact rails and collectors insulated with Keystone Glastic Insulators.



RUNWAY-ORE BRIDGE
equipped with Keystone Glastic Contact-rail Insulator assemblies for under-running contact-rail service.



COKE QUENCHER
Power rails equipped with Keystone wet-process porcelain petticoat-type Insulators providing long leakage distance for wet, dirty applications.

ELECTRIC SERVICE MANUFACTURING CO.,

SERVICE ENGINEERED

KEYSTONE INSULATORS

FOR UNFAILING PROTECTION

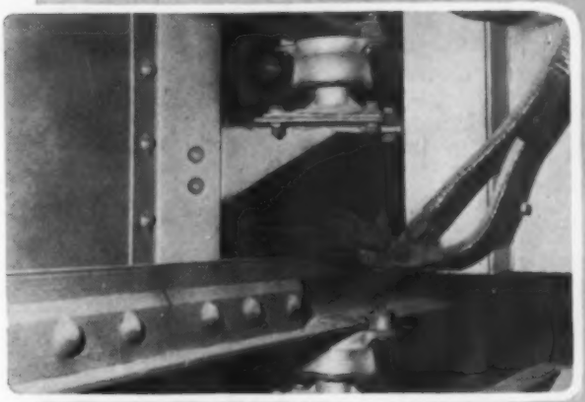
When U. S. Steel engineers built the Fairless Works to be the most modern mill in the world they had to consider every product for peak efficiency. For insulators on power lines and rails Keystone Insulators were selected and installed from the ore unloader right on through the plant.

Keystone Insulators are "service engineered" to take the toughest treatment on all installations. They have been proved and approved by years of unfailing service in the leading industrial plants throughout the world. They include:

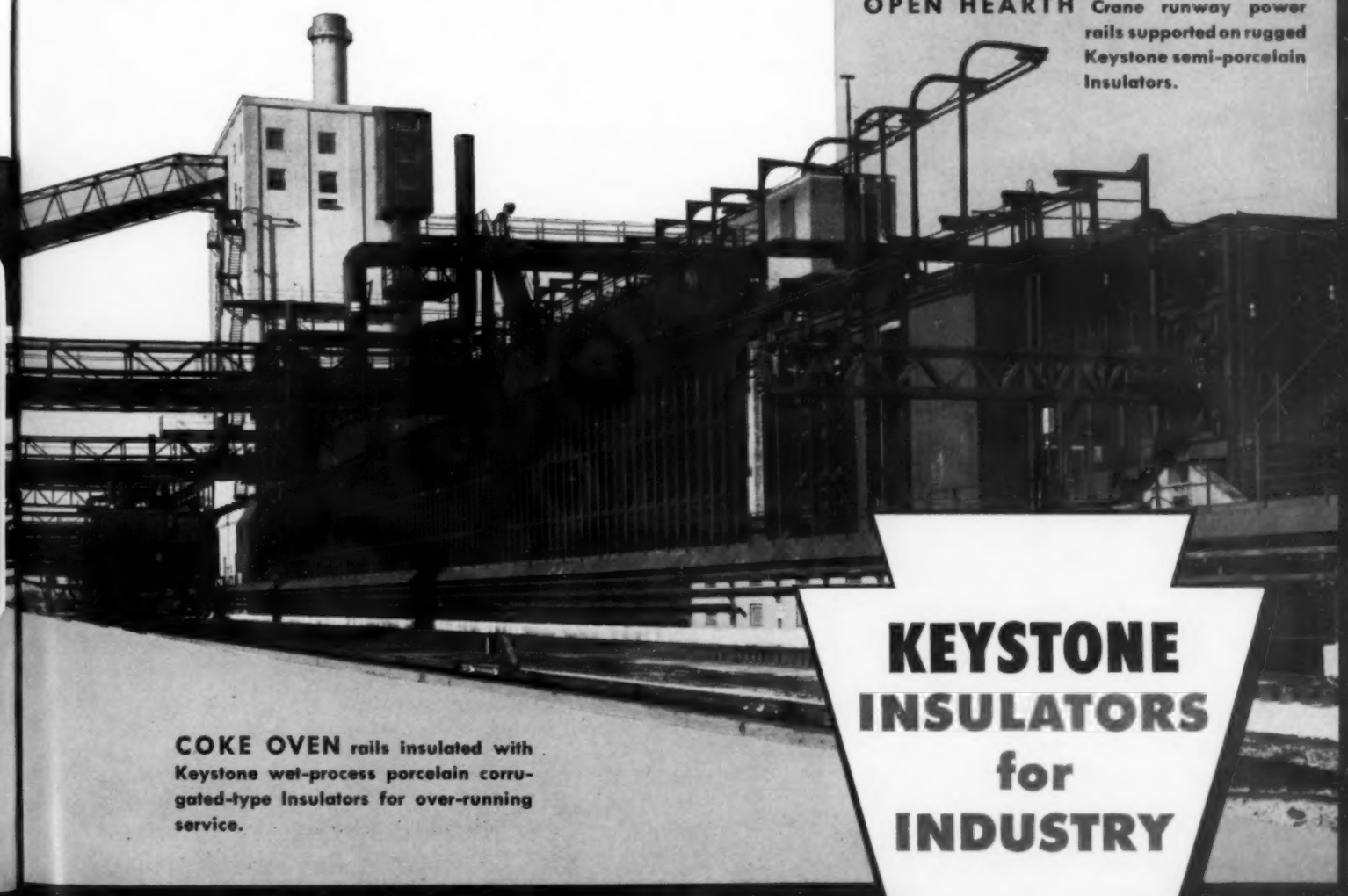
Moulded Glastic Insulators
Wet-Process Porcelain Insulators
Semi-Porcelain Insulators
Moulded Phenolic Insulators

For long, strong life and peak protection there's a Keystone Insulator that is "service engineered" to meet every need in your plant. Let ESM engineers help you select the right mechanical and electrical qualities to solve your problems. Write today for complete catalog on these Insulators, Keystone Collectors and Rail Shoes.

SOAKING PIT Crane runway power conductors equipped with Keystone semi-porcelain type Insulators with Keystone phenolic type Giant Strain Insulators providing double safety.



OPEN HEARTH Crane runway power rails supported on rugged Keystone semi-porcelain Insulators.



COKE OVEN rails insulated with Keystone wet-process porcelain corrugated-type Insulators for over-running service.

KEYSTONE INSULATORS for INDUSTRY

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These two man trolley type unloaders, built by Dravo Corporation, are part of the materials handling equipment at the dock of United States Steel Corporation's new Fairless Works near Morrisville, Penna.

The two unloaders run parallel on a common runway for a distance of 1,000 feet. Each unloader is built to handle a 200-cu. ft. ore bucket or a 400-cu. ft. coal bucket. Coal or ore can be unloaded to railroad cars, to pit storage or to a conveyor belt.

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FAIRLESS WORKS

United States Steel's Newest

by T. J. Ess

BENJAMIN F. FAIRLESS

▲ FAIRLESS Works, United States Steel's first integrated steel plant in the East, is the culmination of long-considered plans, with the final impetus coming from the industry's expansion program to meet national defense needs.

The site selected, acquired in 1949, consists of 3900 acres in Bucks County, Pennsylvania, on a bend in the Delaware River about five miles below Trenton, N. J. and 30 miles above Philadelphia. It was devoted largely to truck farming, and lies in an area rich in historical significance dating back to colonial times.

Ground was broken on March 1, 1951, and the production of coke, iron and steel began on December 11, 1952. Rolling mill facilities came into operation at various times during 1953.

As now constituted, Fairless Works provides facilities for the annual production of 875,000 net tons of coke, 1,134,000 net tons of iron, 2,200,000 tons of steel ingots. Rolling facilities are provided for hot-rolled sheets, cold-rolled sheets, tin plate, merchant bars and steel pipe.

Plant layout is striking for its spaciousness. There is ample room to permit enlarging the plant without affecting productive efficiency. Great care was taken to provide for smooth but flexible flow of raw materials and products through the various operations. The equipment installed is of the most modern designs, although few unproved innovations were used.

Fairless Works represents 175 acres under roof. Buildings are, in general, of conventional steel mill design. The open hearth building is the sloping roof type, with a continuous monitor along the ridge. Mill buildings have flat roofs built up of steel plate, insulation and asphalt, with a continuous ventilator running the entire length, except in the National Tube Division, where individual ventilating units are spaced along the roof. Building siding is of corrugated galvanized sheet except in the sheet and tin departments, where corrugated sandwich type sheet is used. No windows are used in these buildings. They are lighted artificially and ventilated by continuous roof ventilators.

Construction required approximately 800,000 cu yd of concrete, with 45,000 tons of reinforcing steel, principally ½ and ¾-in. rounds and 1 and 1¼ in. squares. The buildings required 175,000 tons of structural steel and another 250,000 tons of steel were used for plant facilities. About 25 miles of concrete and tile sewers were instalied. Construction involved the services of approximately 200 principal contractors, 2000 subcontractors and purchase of supplies and materials from 130,000 other business firms.

As the site ranged only 5 to 16 ft above sea level, (12-ft average), about 10,000,000 cu yd of fill were needed to establish the yard level at the selected 20.0 ft above sea level.

The nature of the site presented some foundation problems. Tests showed soil stratification on the site to be quite erratic, with 75-150 ft of overburden on deep

beds of mica schist. The overburden generally consisted of 5-10 ft of top soil and loam, 10-20 ft of sand and gravel and the balance clay and sand. Studies indicated that spread footings could be safely used on the sand and gravel strata, using a soil pressure of 6000 lb per sq ft.

Where a satisfactory foundation bed was too deep and where loads were to be very concentrated, piling was used. Piling was designed with a maximum load of six tons per sq ft, and a maximum of 55 tons per pile with 3-ft minimum spacing and 70 tons with 3½ ft minimum spacing. Piling sections were 12 in. (55 lb per ft) and 14 in. (73 lb per ft), beam sections.

To prevent underground corrosion of steel piling, piping and lead sheathed cables, an electrical grounding system was installed consisting of about 50 beds of steel ground rods and magnesium anodes, each bed containing from 23 to 100 rods and anodes. The steel ground rods are 1¼ in. x 40 ft, spaced on 10-ft centers. The anodes consist of 1 in. x 20-ft steel rods with a 4-in. square of magnesium cast on the center 10 ft of the rod. Anodes, buried near the steel ground rods, and electrically connected to them above ground, are surrounded with a 6-in. back-fill composed of bentonite, sodium sulphate and gypsum. A life of about 20 years is expected for the anodes. Means are provided for their testing and replacement.

Underground piping is covered with a coating of coal tar enamel, wrapped with asbestos felt, saturated with the same enamel and connected to the ground beds. Lead sheathed cable and copper ground wire are neoprene jacketed, and ground connections to building columns are made above ground.

RAW MATERIALS HANDLING

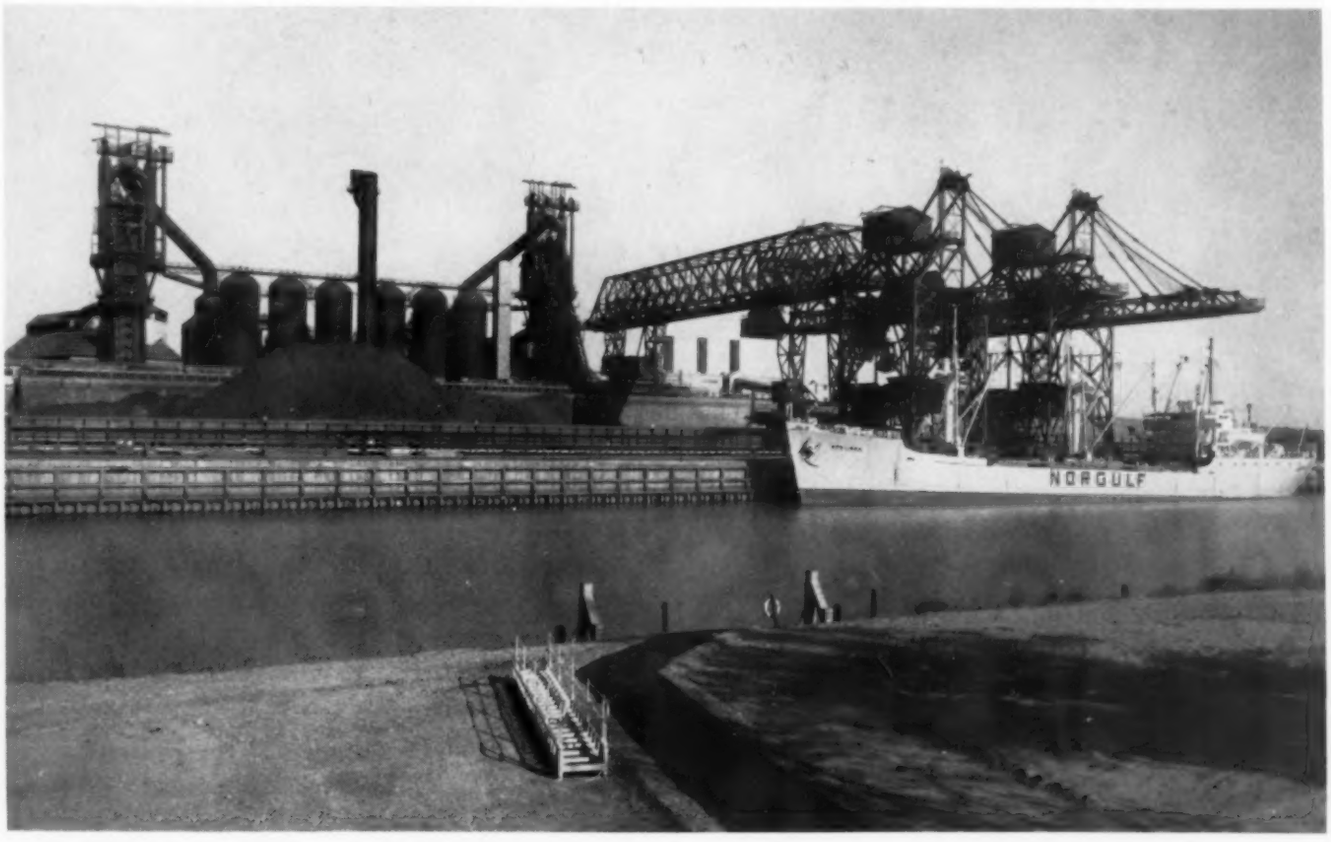
Needless to say, the Delaware River was an important factor in the selection of the plant site. It is anticipated that almost all of the incoming ore will eventually arrive over this route. In addition, fuel oil and various miscellaneous materials can be shipped by water, and of course the shipment of plant products will be facilitated by water shipments.

To take care of docking and unloading barges and ships, a boat slip 350 ft wide x 1000 ft long, with a flared approach from the river another 1000 ft long, was built. It is now 25 ft deep at mean low tide but can be deepened. The slip bulkhead is formed of sheet piling driven 59 ft below sea level, backed up by concrete supported on bearing piles. Along the east wall, this concrete forms part of the dock surface and provides the foundation for the waterside unloader track. The north end of the slip was left with an earth barrier to facilitate future extension of the slip if desired.

Principal materials—ore, coal and limestone—coming into the plant are unloaded either by a car dumper or by two boat unloaders. The car dumper, of the rotary type, will handle cars up to 56 ft in length and 90 tons net capacity at a rate of 30 cars per hour. The receiving hopper beneath the dumper has two 54-in. belt feeders which can handle materials at variable rates up to 1500 tons of ore, 1400 tons of coal or 1000 tons of stone per hour. Cars are spotted, four at a time, by a diesel locomotive on a sloping track and coast down, one at a time, to the dumper.

The two 15-ton unloaders run on a common track paralleling the slip, and have tower legs spaced on 65-ft centers, spanning three railroad tracks and a conveyor

A boat slip, 1000 ft long and 350 ft wide, ties into the Delaware River, providing facilities for water shipments of raw materials and products.



This rotary car dumper will unload railroad shipments of ore, coal or limestone at a rate of 30 cars per hour.

belt. Each unloader has three clam-shell buckets: a 15-ton bucket for ore, a 7½-ton clean-up ore bucket and a 10-ton coal bucket. Hoist speed is 250 fpm, trolley speed 1000 fpm and tower speed 87 fpm. Each unloader has free digging capacity for 1100 tons of ore, 700 tons of coal or 800 tons of limestone per hour.

Each unloader has four receiving hoppers, two of 100-ton capacity each over railroad tracks for car loading, one of 120-ton capacity over a belt conveyor for ore, and the fourth to serve a future conveyor. The hoppers for car loading are equipped with motor-operated cut-off gates, while those serving conveyors have regulating feeders to release 250-1000 tons of ore or 200-800 tons of coal per hour.

Ore or limestone coming in by rail is unloaded by the car dumper and fed to a 48-in. belt conveyor 3600 ft long and discharges to a second conveyor which parallels the ore trough for the full length of the storage yard. A traveling tripper and stacking boom conveyor piles the material in the trough, from where it is removed and deposited in the yard by a traveling bridge.

Ore received by water is removed from the vessels by the unloaders, with the buckets normally transferring the ore to the hopper over the belt conveyor. This conveyor is the one previously mentioned coming from the car dumper.

At present almost all of the coal is received by rail, unloaded by the car dumper and taken by belt conveyors either to storage or to the coke plant. For storage, coal is discharged into a 350-ton elevated hopper, from which it flows into 16-ton mobile carriers for transportation to various storage piles. Bulldozers are used for leveling. The same bulldozers and carriers reclaim coal from storage, moving it to a double hopper where vibrating feeders regulate it to belt conveyors running to the breaker house. Coal can also be taken directly from the car dumper to the breaker house by a 48-in. belt conveyor 1750 ft long.

Coal received by water may be unloaded by the unloaders and placed in railroad cars, which are then handled through the car dumper as described above. If water shipments of coal should become appreciable, another conveyor can be installed under hoppers al-

Two 15-ton unloaders running along the slip handle ore, coal and limestone arriving by ship or barge.

Belt conveyors are used extensively for handling materials. Here ore is tripped from a belt into the trough, from where it is removed by the ore bridge.

ready on the unloaders to move coal to the coal conveyor serving the car dumper.

The coal storage area served by the conveyor system has a capacity of about 400,000 tons of coal.

The ore storage yard, 283 ft wide x 700 ft long, with capacity for 750,000 tons of ore, is served by a 22-ton bridge of 283-ft span with cantilevers of 74 ft 6 in. at the furnace end and 69 ft at the trough end. The bridge speed is 75 fpm, trolley speed 850 fpm, and hoist speed 175 fpm. The storage area lies between two concrete retaining walls, one 44 ft high, the other 20 ft high above the ore yard floor. These walls also act as foundation and runway supports for the ore bridge. The storage area is paved and a concrete trough runs along one side of the area.

At the furnace end of the bridge is a 66-ton hopper which is filled by the bridge bucket, and which discharges into a 120-ton double side-dump transfer car which runs along the blast furnace high line to stock the blast furnace bins.

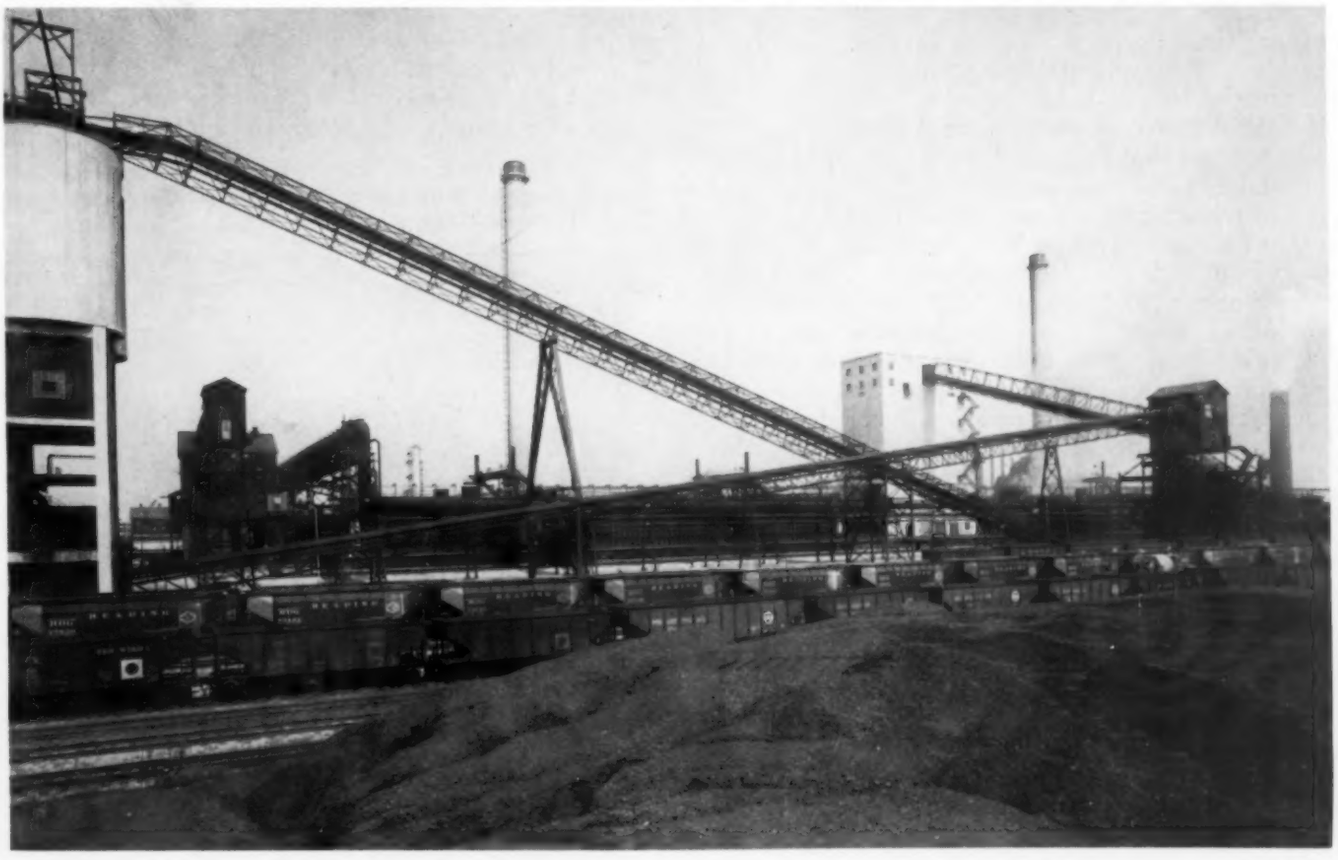
COKE PLANT

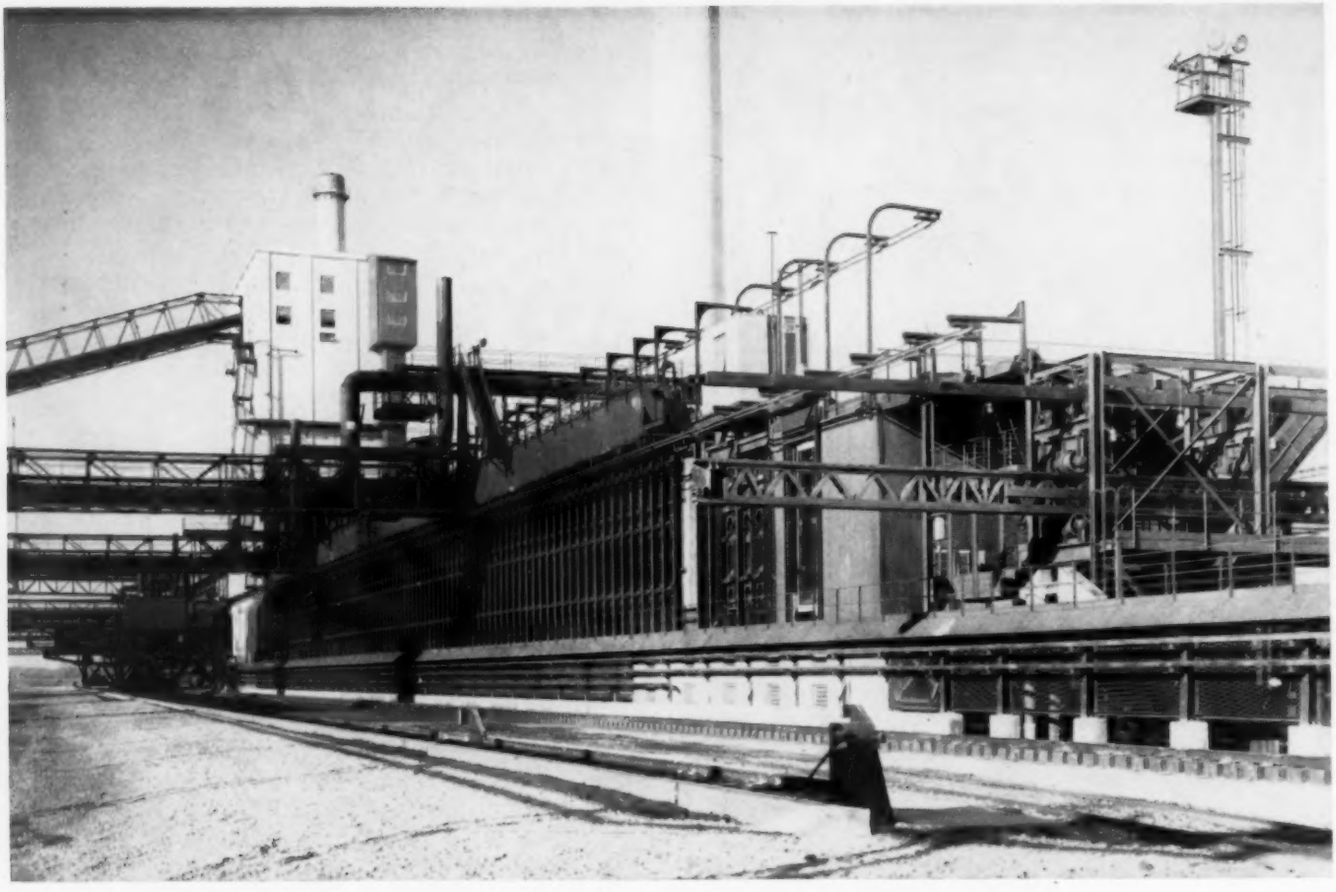
Two batteries of by-product coke ovens, each of 87 ovens, provide facilities for coking 3500 tons of coal per day. Coal, either from storage or direct from the car dumper, is conveyed to a 700 tons per hr breaker, where it is crushed to 2½ in., and then taken by conveyor to four 700-ton mixing bins, each 32 ft in diameter x 61 ft high. From these bins, coal is taken as desired by four weighing conveyors which lead to two 350 ton per hr hammer mills, where it is further crushed so that 80 per cent will pass through a ⅛-in. screen. A mixture of 80 per cent high volatile and 20 per cent low volatile coals is generally used.

A belt conveyor carries the crushed coal mixture to a concrete oven bin of 3700 tons capacity. Three-hopper charging lorries move the coal from this bin to the individual ovens.

The ovens, 40 ft 7⅝ in. long x 12 ft high x 18½ in.

View of the coal storage area, with coal conveyors and coke ovens in the background.





Two batteries of underjet coke ovens, of 87 ovens each, coke 3800 tons of coal per day.

average width, with a 3½ in. taper, are of low differential, four-divided, underjet design. Continuously welded steel flashing plates in the bus flues at the base of the ovens prevent gas leakage between the different passages. The ovens are fired with coke oven gas and have provisions for the future use of blast furnace gas if desired. The ovens take a normal charge of about 16 tons each and have a normal coking rate of 17.4 hours, or a total of 240 ovens per day.

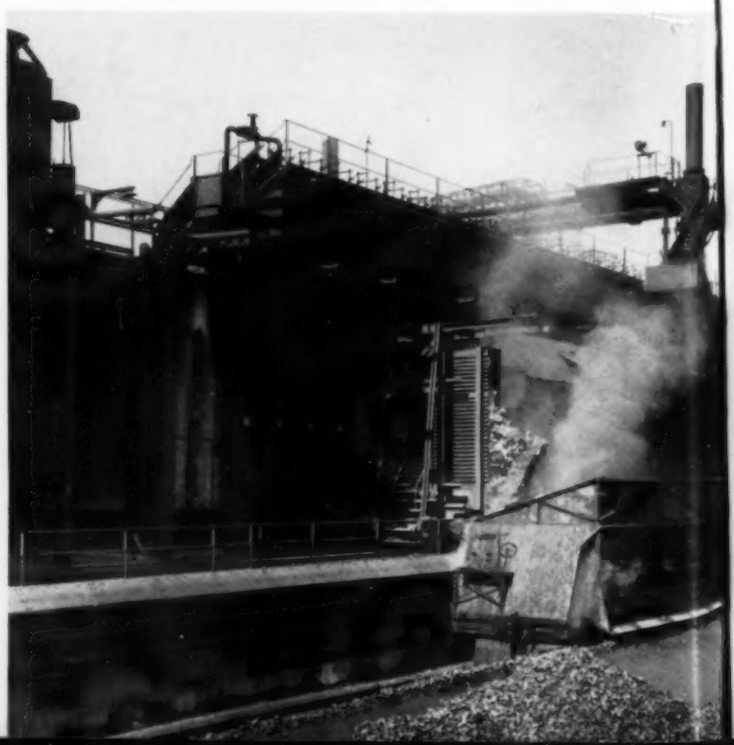
Two pusher machines push coke into 40-ft quenching cars which are moved by a 20-ton electric locomotive to the quenching station. The quenched coke is then spread over a 300-ft coke wharf, and when sufficiently cooled, is carried by a 42-in. belt conveyor to the screening station. Here a disc type grizzly separates the coke into + or −4 in. The + 4-in. coke is put through an adjustable roll crusher and then over a double deck screen. The −4 in. sizes go directly to this screen, where they are separated into +¾ in., −¾ in., and −⅜ in. There are two of these screens side by side on a movable carriage, so that one may be repaired while the other is in use.

Furnace coke is normally taken to the blast furnace bins by a 48-in. belt conveyor 5511 ft long. In emergencies, furnace coke may be loaded into railroad cars by a boom conveyor which is normally used to load nut coke into cars. Breeze is discharged into railroad cars by chutes.

By-product recovery follows, in general, the conventional pattern. Two primary coolers, 15 ft in diameter x 68 ft high, and electrical precipitators remove tar from the gas, which then passes through two ammonia scrubbers 7 ft in diameter. Ammonium sulphate is produced by a controlled crystallizer system and dried in a thermal rotary dryer 80 in. in diameter x 45 ft long.

Surplus ammonia liquor is scrubbed with light oil in a unit 10 ft in diameter x 65 ft high, and the phenolized light oil is treated with caustic soda in a tower 12 ft in

Each oven is charged with 16 tons of coal and produces 11½ tons of coke.



Coke is moved from the coke plant in the distance to the blast furnace bins by a 48-in. belt conveyor 5511 ft long.

diameter x 60 ft high, producing sodium phenolate. The dephenolized liquor is concentrated in an ammonia still, 5 ft in diameter x 34 ft high, and the ammonia is put back into the gas stream ahead of the ammonia absorbers for the production of ammonium sulphate.

The gas then passes through a final cooler 16 ft in diameter x 73 ft high and then through two light oil scrubbers 12 ft in diameter x 116 ft high. These scrubbers are of spray type instead of the more usual packed column design. A wash oil still and a crude residue removal column complete the equipment for the production of crude light oil.

Surplus gas mixed with natural gas and air, is used for metallurgical fuel. The gas is distributed at a pressure of 7 psi.

BLAST FURNACES

Coke is delivered from the coke plant to the blast furnaces by the conveyor belt previously mentioned, or in emergencies, by hopper cars. Each furnace has eight coke bins, totaling 600 tons capacity. The two central bins at each furnace (180 tons capacity) are for nut coke and emergency use, and discharge directly into the weigh hoppers without screening. The other six bins (420 tons capacity) discharge through vibrating feeders to 60-in. belt conveyors leading to a single-deck vibrating screen which removes sizes smaller than ⅝ in. The larger sizes go to the weigh hopper, while the breeze collects in a hopper under the screen and then is transferred by conveyor to a storage hopper for loading into trucks or cars.

Thirty-three additional bins complete the high line of the two furnaces and provide storage for 2200 tons of ore, 550 tons of limestone, and 700 tons of miscellaneous materials. All of these materials are brought to the bins either by the ore bridge and transfer cars or by hopper cars. Running over the high line are the

Iron is produced by two 28-ft hearth blast furnaces which are tapped every five hours.

ALBERT J. BERDIS

General Superintendent

H. E. WARREN, JR.

Assistant General Superintendent

coke conveyor and two tracks, one for the two transfer cars, and one for miscellaneous cars.

The stock bins discharge through quadrant type bin gates, actuated by the scale car operator, directly into 40-ton double compartment scale cars which travel at speeds up to 500 fpm.

The furnaces are charged by conventional double skips with 300-cu ft cars dumping into revolving distributor tops, all under automatic control. Large and small bells are operated by pneumatic cylinder hoists powered from the cold blast.

The two blast furnaces, each rated at 567,000 tons per year, are duplicates, with 28 ft hearth diameters, 31 ft 3 in. bosh diameters, heights of 105 ft from iron notch to top ring, and working volumes of 47,345 cu ft from tuyeres to stockline. The hearths are cooled by cast iron staves, while copper cooling plates are used in the bosh and up into the stack for a distance of 50 ft above the mantle. Abrasion resistant steel wearing plates protect the stock line.

The furnaces have hearth walls of carbon brick and shapes extending from the bottom of the hearth jacket cooling staves up to the center line of the tuyeres. The bottom is built up of high duty hard-burned hearth brick. Above the carbon walls, hard-burned hearth and bosh quality refractories are used. The inwall section is lined with firebrick burned to cone 18 and, nearing the stockline, to cone 23.

Blast is furnished to the furnaces by three five-stage 110,000-cfm, 35-psi turbo-blowers. The blast for each furnace is heated by three-side combustion, two-pass stoves, 28 ft in diameter x 125 ft high, providing a total heating surface of almost 1,000,000 sq ft. The stoves are heated by clean blast furnace gas introduced through proportioning pressure type burners. Blast temperature is controlled by means of an automatic mixing valve.

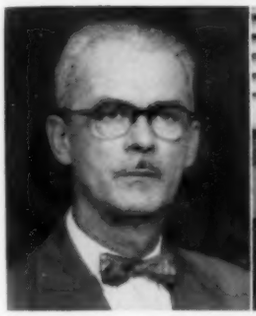
Gas leaves the furnace through four lined offtakes 6 ft 6 in. in diameter, which unite into two uptakes which in turn combine in a single downcomer of 11 ft diameter. The gas is cleaned by passing through, in series, a 41 ft 6 in. diameter dust catcher with a double screw pug mill at the bottom, a 21-ft diameter spray tower washer containing two sets of sprays and four banks of tile grids, and two electrostatic precipitators in parallel.

Water discharged from the gas washers and precipitators flows to a thickening basin 90 ft in diameter 21 ft 9 in. deep at the center and 15 ft 1 in. deep at the outer rim, providing a settling period of 1 hr-20 min. Sludge is pumped out of the thickener into settling basins. Effluent from the thickener goes to a clarification plant which is subsequently described in this article.

The furnaces are tapped into 200-ton mixer type ladles. Only basic iron is produced, principally for direct use as hot metal in the open hearth. If desired, however, iron may be cast into pigs on a double strand casting machine.

Slag flows into two-compartment dry slag pits 100 ft x 240 ft. After solidifying, it is removed by a power shovel and loaded into trucks.

A ladle house in which the charging end of the pig machine is located provides facilities for inspecting, repairing and lining the ladles. A 600-ton track scale is located nearby.



E. R. MILLER
Division Superintendent
Coke Plant & Blast Furnace

H. A. PARKER
Division Superintendent
Steel Producing

T. J. KOENIG
Division Superintendent
Rolling Division

A. C. BLEDSOE
Division Superintendent
Sheet & Tin Finishing

H. S. SPITZ
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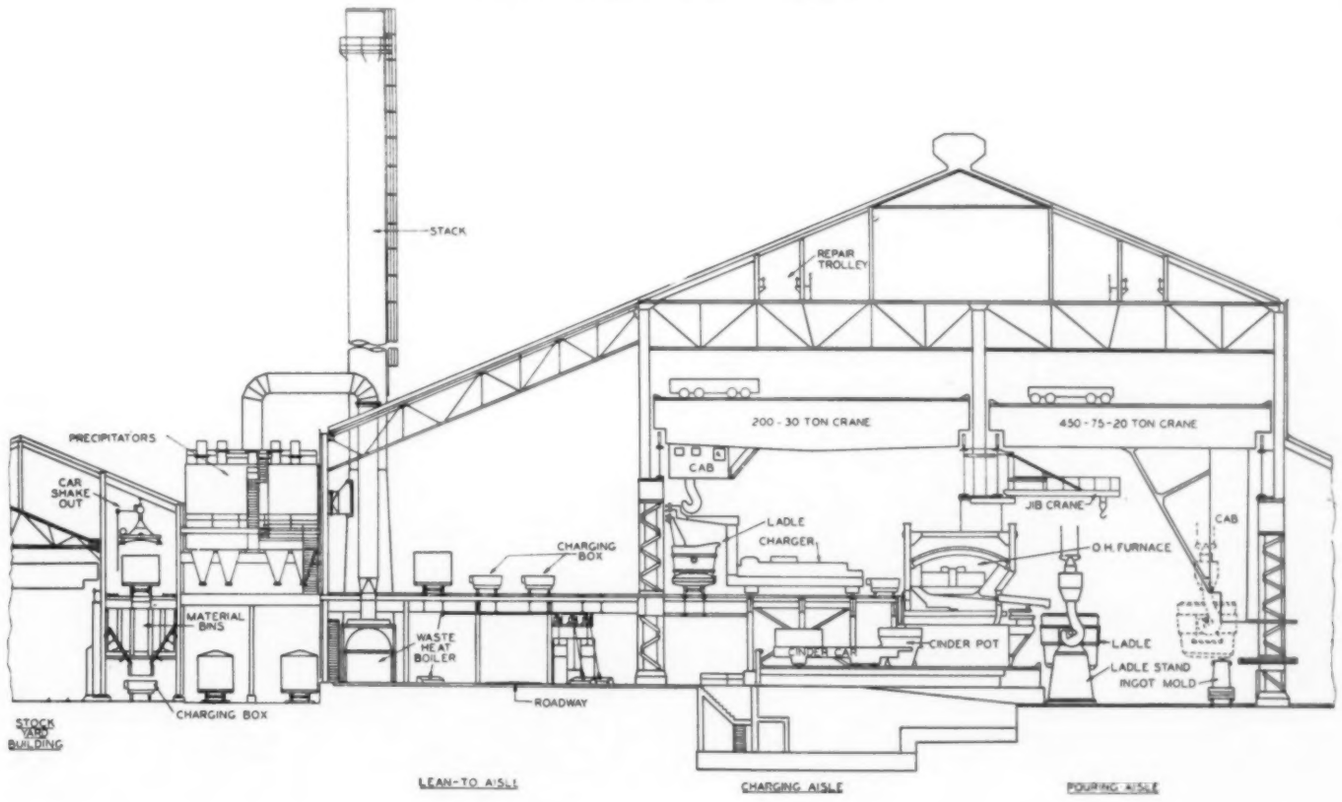
Plant Industrial Engineer

J. R. DEMBECK
Works Auditor

OPEN HEARTH

The open hearth department is located between the coke plant and blast furnace areas on one side and the rolling mills on the other side, and is laid out diagonally between these areas, simplifying trackage connections. The main building is made up of three parallel aisles: the lean-to, 1287 ft x 85 ft, the charging aisle, 1287 ft x 88 ft, with four 15-ton charging machines

Cross-section of open hearth building.



and three 200/30-ton hot metal cranes, and the pouring aisle, 1404 ft x 79 ft, with three 450/75/20-ton ladle cranes and three pouring platforms, one 351 ft long and two 410 ft long. Except for the area around the ladle and slag pot stands, the floor of the pouring aisle is paved with concrete. The width of the lean-to permits the installation of four tracks, eliminating congestion in handling and holding raw materials.

The stock yard, paralleling the main building but on ground level, is 1287 ft x 87 ft 9 in., and contains four tracks, two for gondola cars and two for charging buggies. It is served by three 15-ton cranes equipped for magnet operation. Provisions are also made for weighing charging buggies while they are in motion. A storage bin 20 ft 8 in. wide runs the full length of the building. Scrap preparation is carried on in another building served by two 15-ton cranes and containing two 30-in. shears, and two 500-ton balers which form 1500-lb bales 18 in. x 24 in. x 36 in.

Ore and stone are unloaded directly from cars into storage bins adjacent to the stock yard but on charging floor level. These bins discharge directly into charging boxes on their buggies on ground level.

Dolomite is unloaded from hopper cars on the charging floor level into storage bins in the lean-to and elevated by skip hoist to another bin above the charging floor. From here it flows by gravity into the hopper of the dolomite machine.

Ferroalloys are prepared for ladle addition as they are unloaded from cars at charging floor elevation by passing them through a crusher car located as desired over one of five bins. The alloys flow from the chutes into drop-bottom buckets which are moved by crane to the tapping platforms. A jib crane is provided at each of these platforms.

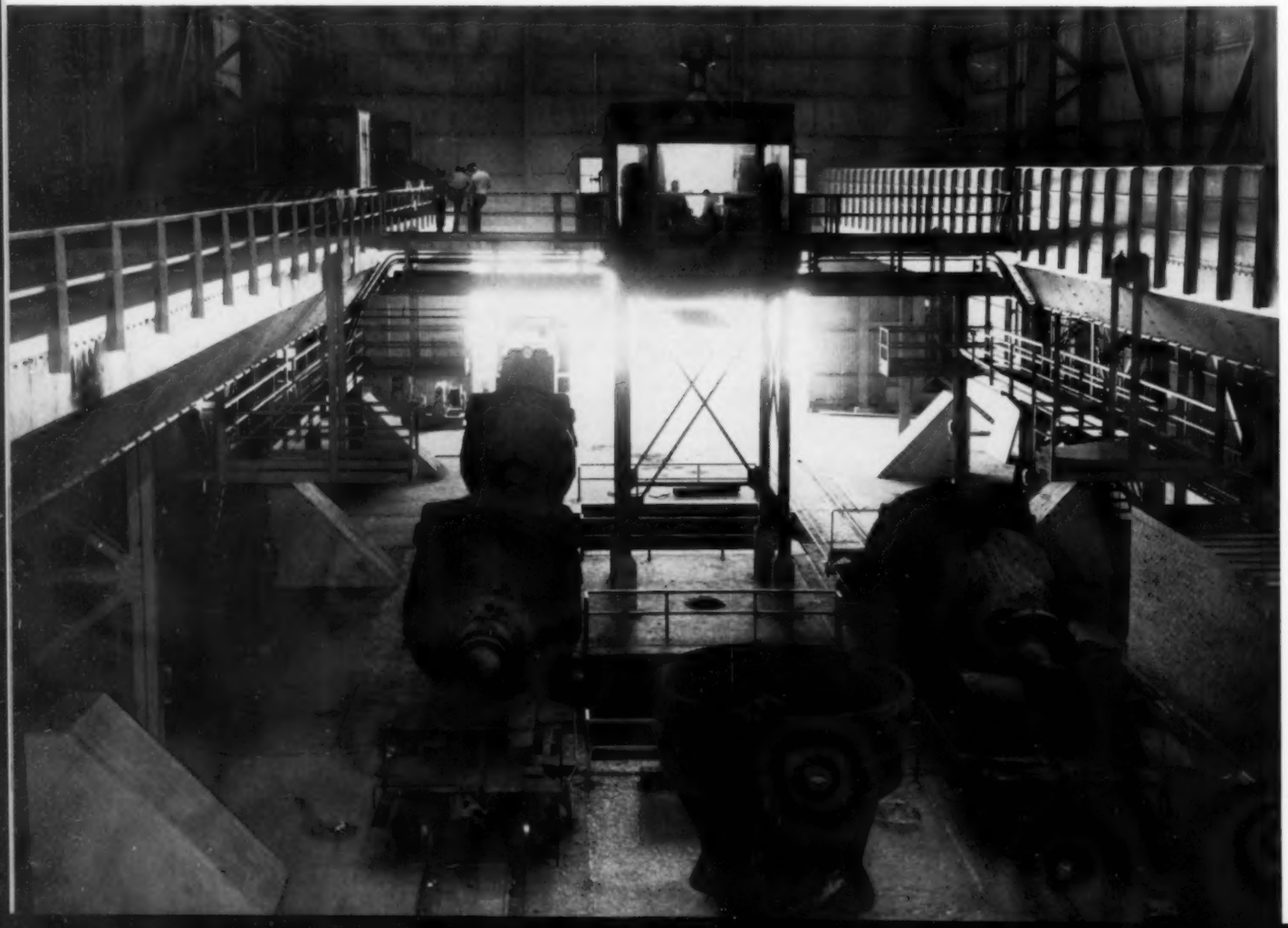
Refractories are stored in a brick storage building located in the yard south of the open hearth.

Hot metal comes to the open hearth in 200-ton mixer type ladles from which it is poured directly into the open hearth hot metal ladle which rests in a pit between the two hot metal tracks at the end of the building. This ladle is then placed by crane on to a hot metal transfer car and carried to the furnace for which it is intended, where another overhead crane empties it into the furnace.

The nine 290-ton open hearth furnaces are spaced on 117-ft centers and are 94 ft 3½ in. over-all length inside the steel work. Hearth dimensions at the sill line are 60 ft x 18 ft 6 in., affording a hearth area of 11-10 sq ft. The bottom is 39½ in. thick at the center of the furnace, made up of 1 in. of insulating concrete, 18 in. of chrome brick, 9 in. of magnesite brick and 11½ in. of rammed bottom material.

The sloping back wall is composed of 22½ in. of chrome-magnesite brick above the sill level, thickening out below the sill line and topped by a layer of rammed material tapering down from 10 in. thickness. Front walls are built of 13½ in. of chrome brick, 9 in. of magnesite brick and about 10 in. of rammed material below the sill line. Front piers above the foreplate are of metal encased chrome magnesite brick 22½ in. thick at the bottom and 18 in. thick toward the top. The five

Mixer type ladles of 200 tons capacity bring hot metal to the open hearth, where the metal is poured into ladles and taken to the furnaces by cranes and transfer car.



charging doors are 6 ft wide so as to accommodate the 50 cu ft charging boxes.

The furnace roof, with a span of 23 ft 10½ in. and a 3 ft 6 in. rise, is 18 in. thick with 24-in. ribs every fourth ring. Standard silica brick is used except for a 4-ft row along the front skewback and a 6-ft row along the back skewback, where superduty silica brick is used.

Port ends and side walls are built of chrome magnesite brick with an outer wall of silica brick. Port roofs, with a span of 20 ft 1½ in. and a rise of 2 ft 11¼ in., are constructed of silica brick 18 in. thick with 24-in. ribs every sixth ring.

On each furnace, two water cooled oxygen jet devices may be inserted through the back wall across from the end doors for decarburization purposes. They operate on a track arrangement so they can be retracted when not in use.

Two 61.15 sq ft uptakes on each end of the furnace connect into a single slag pocket with a cross-sectional area of 270 sq ft and an effective volume of 4250 cu ft. Uptake walls are of chrome magnesite brick 13½ in. thick. Suspended construction is used in the chill walls, fantail noses and fantail arches. Slag pockets have 22½ in. firebrick walls with silica brick false walls, and are insulated with 4½ in. of insulating block.

Double regenerator chambers on each end, 37 ft 6 in. x 29 ft inside, contain checker work of two-pass design to a depth of 16 ft 6 in. Checkers are designed with solid vertical flues, 9 in. x 9 in. in the first pass and 7½ in x 7½ in. in the second pass. Checkerwork volume on each end of the furnace totals 7884 cu ft in the first pass and 6116 cu ft in the second pass, for a total of 14,000 cu ft. The idle pass, which is separated from the first and second checker passes by 13½ in. walls, has a passage area of 83.4 sq ft.

Regenerator roofs are of semi-silica brick 10 in. thick, with flat suspended construction, covered with 2 in. of insulation. Regenerator walls are of first quality firebrick 18 in. thick, covered with 4½ in. of insulation.

Furnace binding consists of slab buckstays 6 in. x 18 in. along the front and back walls and 5 in. x 15 in. on the port ends, rigidly bound by heavy structural members. Skewbacks are 33 in., 240-lb beams, with the bottom flanges water cooled. Front wall buckstays are also water cooled. Back buckstays are shaped to give a 51 degree slope to the back wall. Buckstays on slag pockets and regenerator chambers are heavy I-beams.

Separate flues for each regenerator chamber lead to individual reversing valves and provide a combined area of 85.2 sq ft on each end of the furnace. Past the reversing valves, the two flues merge into one leading to the stack or branching off to a waste heat boiler. Second quality fire brick is used for flue construction, 9 in. thick on the floor, 13½ in. thick for the walls and 9 in. thick for the arches. Floors are backed up by 2¼ in. of insulating concrete and 5½ in. of common brick, and the walls with 4½ in. of insulating brick. Arches are covered with 4½ in. of insulating brick and 4½ in. of common brick.

A horizontal tube waste heat boiler is installed for each furnace, designed to produce about 21,000 lb of 300 psi, 620 F steam per hour, while reducing the temperature of 160,000 lb per hour of waste gas from 1150 F to 550 F. Induced draft fans, capable of handing 235,000

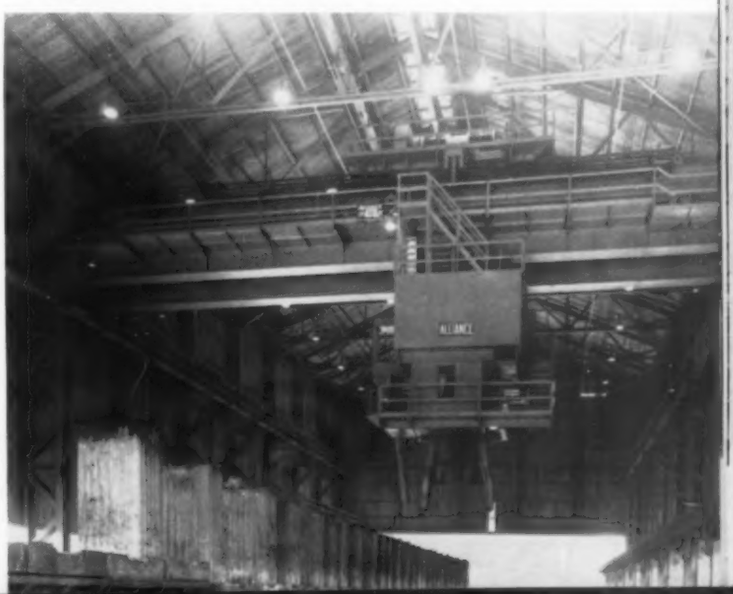
The open hearth furnaces, of 94 ft 3½ in. overall length, have two-pass checkers and are completely equipped with automatic controls and instruments.

lb per hour of waste gases at 575 F, 8-in. water column, are driven by 250-hp turbines. Waste gases leaving the boiler pass through two dry type electrostatic precipitators, 48 ft long x 15 ft 6 in. wide x 38 ft high, elevated above the railroad tracks adjacent to the lean-to. In this cleaning process, the particles cling to baffle plates from which the material is shaken by pneumatic vibrators into hoppers. Dust is removed from the precipitator hoppers to a pug mill by a vacuum system. The wetted dust is discharged from the pug mill to side dump cars below. This same vacuum system is used to clean the furnace checker chambers and flues.

Furnace stacks, 225-ft high, are of welded steel construction and lined with second quality fire brick ranging in thickness from 38 in. at the bottom to 4½ in. at the top. Diameters inside the brickwork vary from 8 ft 8 in. at the bottom to 9 ft 3 in. at the top.

Water cooled artillery type burners introduce fuel oil or tar or a combination of the two through the furnace ends. They are designed for a maximum input of 1000 gal per hr at 130-200 psi pressure, and can handle oxygen for combustion purposes if desired. Air for combustion comes from forced draft fans rated at

In the stripper building, located near the soaking pits, two 400-ton stripper cranes remove molds from the ingots.



26,000 cfm, 6-in. water column. Separate recirculating loop systems are installed for oil and tar.

Each furnace is completely equipped with instruments and controls, including furnace pressure control, roof temperature control, fuel input control, checker differential temperature control, checker temperature recorder, bath temperature recorder, flue temperature indicator, steam flow control, oxygen flow control for combustion and decarburization, liquid fuel pressure and viscosity controls. The furnaces may be reversed by differential checker temperatures or time interval, or manually, with the controls governing air valves, fuel valves, steam valves and oxygen valves. All instruments and controls for each furnace are mounted on a panel board which forms the front wall of a control house.

Steel is produced in a wide variety of carbon and alloy grades, and is poured into molds ranging 32-78 in. wide x 22-29 in. thick x 80-94 in. long, with weights ranging 14,000-32,270 lb. They are then shifted to the 288 ft x 96 ft stripper building near the soaking pits, usually a full heat at a time. Here two 400-ton stripper cranes remove the molds from the ingots, which are then taken to the soaking pits.

The furnaces are designed for front and back flushing into 600 cu ft slag pots. For front flushing, the pot is carried on a special car running beneath the furnace hearth between the slag pockets. Slag pots are handled by crane to a two-pot car on the slag track. Slag is taken to a dump and processed.

Molds are returned to the mold preparation building, which is 1579 ft x 89 ft, is served by one 60/25-ton and two 30/10-ton cranes, and contains two mold coating stations and hot topping platforms. Molds are coated by filling them with the coating material and allowing them to drain.

Miscellaneous equipment used in the open hearth department includes a stopper rod press, stopper rod oven, dolomite machines, fifteen 200-ton mixer type ladles, two hot metal transfer cars, one electric locomotive, fourteen 300-ton open hearth ladles, 300 charging cars (four boxes each) and 260 ingot buggies.

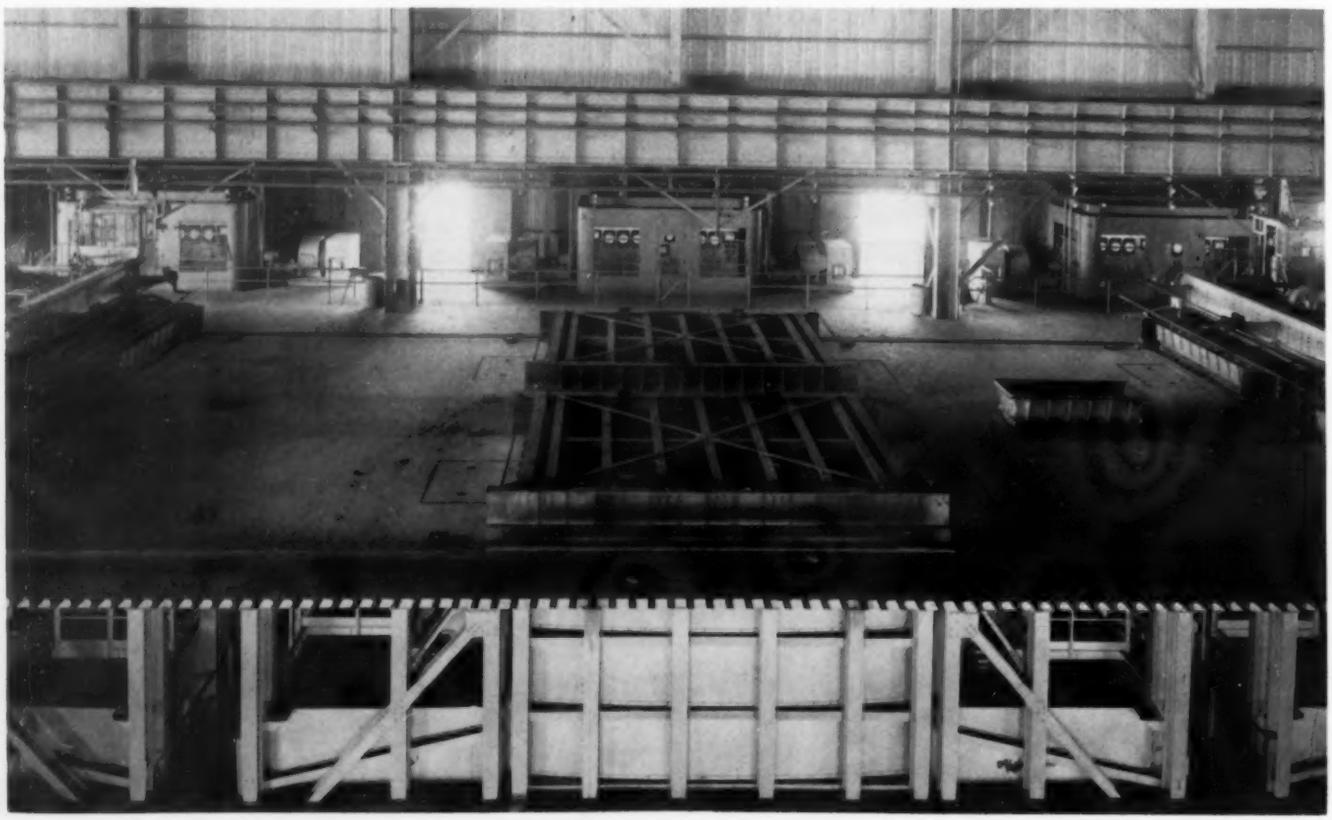
45-IN. SLABBING MILL

Ingots are heated in 20 one-way fired recuperative soaking pits, arranged in a double row. Each pit is 20 ft long x 14 ft 6 in. wide x 14 ft deep, and is fired with a mixture of natural-coke oven gas through two burners near the top of the pits, directed so as to impart a whirling action to the hot gases in the pit. The pits are provided with refractory tile recuperators capable of heating air for combustion to 1600 F. An 8000-cfm blower supplies air to each pit. Automatic controls regulate temperature, fuel-air ratio and furnace pressure on each pit.

Three 40-ton cover cranes span the double row of pits and remove and replace pit covers as required.

Ingots are handled into and out of the pits by three 30-ton pit cranes of 106-ft span. Four tracks run the length of the soaking pit building, paralleling the row of pits. Two of these are connected to the plant railway system and run through the stripper building, while the other two tracks accommodate two ingot buggies. Each buggy has a cable attached at each end, and is pulled back and forth by a 200 hp motor-operated drum at each end of the track. Both cables are under

Ingots are heated in 20 soaking pits arranged in a double row. The pits are recuperative and fired with a mixture of natural and coke oven gas.



tension at all times. The drives are designed for a maximum speed of 1008 fpm, and are equipped with automatic positioning systems with push-button controls for spotting the cars at the soaking pits. The buggy is automatically accelerated to maximum speed, decelerated as it approaches the ingot receiving table, and inched into a tilting device. As an ingot car approaches the ingot receiving table, cam levers on each side engage cam casting bolted to the foundation, tipping the pot as the car stops at the table.

Each car unloads its ingot upon a 13 ft 5 in. individual stationary receiving table carrying seven motor-driven table rollers, from which the ingot is moved to an 11-ft moving ingot table mounted on a car frame which moves traversely to line up with mill approach table.

The approach table is 51 ft 9 in. long and includes a motor-operated overhead type ingot turnaround with a 50-ton scale and weight recorder.

The slabbing mill is of the universal type, with vertical rolls integral with the main mill housing. The horizontal rolls are 45 in. in diameter x 9 in. body length. The bottom halves of the top and bottom roll necks run in babbitted bearings, with composition bearings on the top halves. The rolls are adjusted by screws of 16 in. diameter and 2½ in. pitch, driven by two 200 hp d-c motors under adjustable voltage control. Roll lift speed may range up to 600 in. per minute, and a maximum roll lift of 78 in. is available. The top roll and spindle are balanced by counter weights.

Vertical rolls, 37 in. in diameter x 96 in. body length, are located 8 ft 3 in. beyond the horizontal rolls and operate in roller bearings. Their position is adjusted by two 150-hp d-c motors up to a maximum opening of 90 in. These motors operate in unison, with no mechanical or electrical tie between the two mechanisms. The master control for this system is adjusted so closely that errors in roll alignment are negligible.

On both sides of the mill are movable sideguards, operated through racks and pinions by four 200-hp d-c motors and provided on both entry and delivery sides with manipulator fingers actuated by two 150 hp d-c motors, all under adjustable voltage control.

On each side of the mill are three feed rollers individually driven by six 17-hp d-c motors. Front and back tables are 34 ft 11 in. long, each driven by two 200-hp d-c motors, also under adjustable voltage control.

The mill runout table, 76 ft 8 in. long, and the shear approach table, 74 ft 11 in. long, are each driven by two 100-hp d-c motors. These tables, as well as those preceding and following, are equipped with anti-friction bearings.

Scale is removed from the ingot by hydraulic sprays at the mill. Water comes from a 6-stage, 1250-gpm, 1600-psi pressure centrifugal pump, driven by a 1500-hp, 2300-volt induction motor.

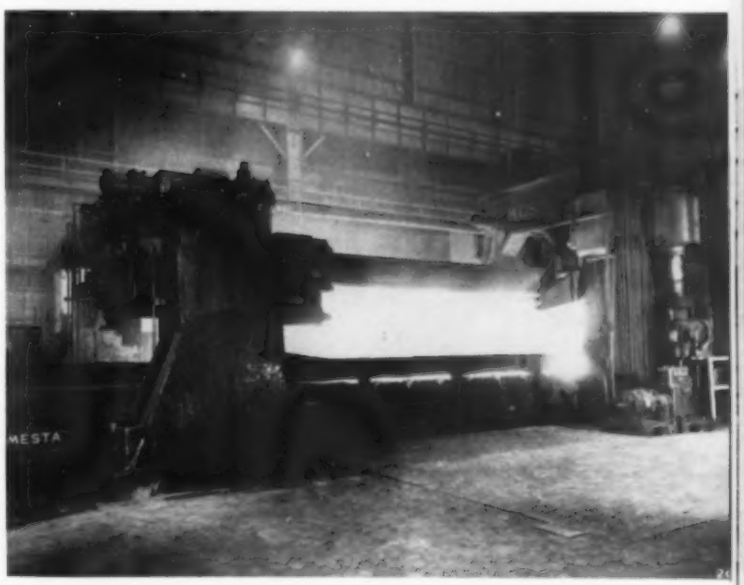
The 45-in. universal mill is driven by a 16,000-hp reversing drive consisting of a 6000-hp, 40/80-rpm, 700-volt, d-c double armature motor on each horizontal roll and a 4000-hp, 60/150-rpm double armature motor on the vertical rolls. The horizontal rolls are connected to their motors by universal spindles 30 ft long, while the vertical rolls are driven through fixed right-angle reduction gears and vertical universal spindles.

The 45-in. slabbing mill, powered by a 16,000-hp reversing drive, operates at speeds up to 941 fpm. Mill auxiliaries operate under adjustable voltage control.

Direct-current power for the complete drive comes from an eight-unit motor generator set having four 2500-kw, 700-volt generators for the horizontal roll drives, two 1750-kw, 700-volt for the edging roll drive, a 215,000 hp-sec steel plate flywheel 14 ft in diameter, and an 8000-hp, 13,800-volt, 514-rpm wound-rotor, induction motor.

The arrangement of main circuits and field circuits of this drive is such as to reduce possible short circuit currents, eliminate many circuit breakers and all but one load balance circuit. Exciters and regulating exciters are applied so as to give quick response characteristics. Contactors in the master circuit are set to give all motors full field excitation when the mill is at rest. When the pedal of the master switch is depressed for either direction of rolling, the voltage of all gener-

A 2500-ton up-cut hydraulic slab shear cuts slab sections up to 8 in. x 74 in. or blooms up to 22 in. square.



ators is increased simultaneously. After full voltage has been reached, the field current of all motors is reduced at the maximum rate permitted by the current limit circuits until the desired maximum speed is reached.

The 45-in. mill drive has been set to give a reversal time of 1.5 sec from base speed in one direction to base speed in the opposite direction.

The two armatures of each 6000-hp motor are connected in series with the two generators for the drives. The voltage drop of the commutator field for each motor generator loop is used in the load balance circuit to control the load balancing field of the generator. This balances the load on the rolls, regardless of their diameter.

To prevent the edger from carrying more load than its share, the edger drive has a drooping speed characteristic. Rheostats in the field control of this motor adjust speed relations for varying diameters of horizontal and vertical rolls. The control also provides for a slightly lower speed for the edger motor when the ingot is moving from the edging rolls to the main rolls to compensate for elongation in the main rolls.

Auxiliaries of the 45-in. mill, including front and back mill tables, feed rollers, screwdowns and manipulators operate under adjustable voltage control, the drives receiving power from two eleven-unit motor-generator sets, each composed of six 200-kw generators, two 150-kw generators, one 100-kw generator, one 75-kw exciter and one 1250-hp, 1200-rpm, 2300-volt synchronous driving motor. The main control element in this system is a regulating system which causes the generators to operate at about 200 per cent voltage at light loads, and limits the maximum current at 250 per cent. These characteristics provide maximum acceleration and deceleration without damage to the motor.

The mill runout and shear approach tables also operate under adjustable voltage control, with power supplied by a motor-generator set composed of four 100-kw generators driven by a 500-hp, 2300-volt induction motor.

The slabbing mill is designed to roll ingots with a combination of any two of the maximum sizes of 32 in. thickness, 78 in. width of 90 in. length, with a maximum weight of about 40,000 lb, into slabs 16-74 in. wide and 4-8 in. thick, or into blooms up to 14-16 in. x 18-22 in. Maximum rolling speed is 941 fpm.

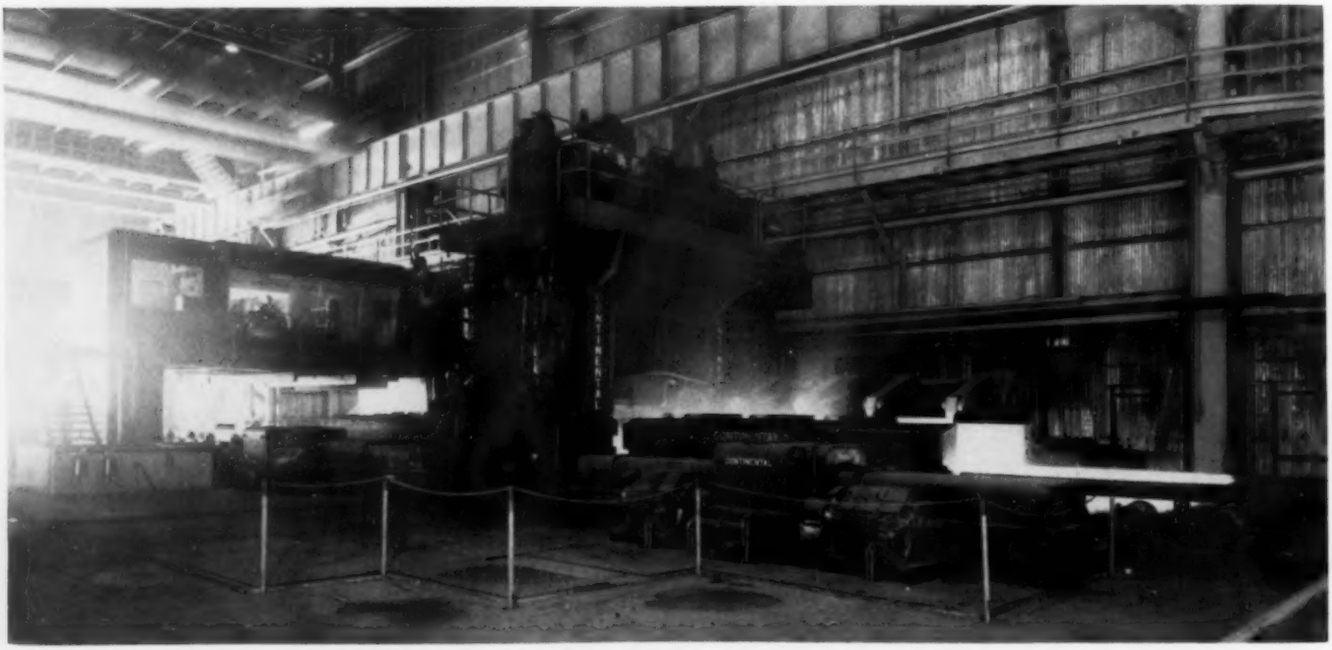
Following the 45-in. mill at a distance of 134 ft is a gas scarfing machine with fume collecting hood and electrostatic precipitator, and 77 ft. farther, a 2500-ton upcut hydraulic slab shear with maximum stroke of 25 in. The pumps for operating the shear are driven by two 300-hp, 2300-volt induction motors. This shear is designed to cut slabs up to 8 in. x 74 in. and blooms up to 22 in. square, and is equipped with a motor-operated shear gage for lengths of 4-21 ft. Crops from the shear drop through an opening formed by a pullback at the delivery side of the shear and are chuted to a heavy chain and drag bar conveyor. A 20-ton recording suspension scale is installed in the back shear table so that slabbing mill product may be weighed.

Steel leaving the slabbing mill may follow any one of three routes. Slabs intended for the hot strip mill may be moved to the left over a 16 x 115 ft transfer leading to the slab furnace charging table in the slab yard, or they may proceed straight ahead to the hot strip mill for direct rolling. Slabs or blooms to be further rolled in the intermediate mill and billet mills are carried to the right over a 234 x 22-ft rope type transfer to the approach table of the 40-in. mill.

BLOOMING AND BILLET MILL

The 40-in. mill is a high-lift, two-high reversing blooming mill, with rolls of 96 in. body length running in oil film bearings. The top roll and its spindle are balanced hydraulically, with a maximum lift of 51 in. Mill screws are 13 in. in diameter, with 1½ in. pitch,

This 40-in. reversing blooming mill receives blooms 22 in. x 16 in. or smaller from the 45-in. mill and reduces them to 9 in. x 9-in. blooms or 11 in. x 7-in. slabs.



and are operated by two 150-hp, d-c mill type motors. Front and back mill tables are 23 ft 4 in. long, each driven by two 100-hp motors, and are equipped with manipulator sideguards and tilting fingers on both sides of the mill. Four 100-hp motors drive the manipulator racks and two 100-hp motors operate the manipulator fingers. On each side of the mill there are two feed rolls, each pair driven by a 50-hp motor. The stand is equipped with a special hydraulic rig for rapid roll changing.

The mill is equipped with twin-drive motors, with each roll driven separately and directly by a 4000-hp, 65/130-rpm, 700-volt single armature motor, giving delivery speeds up to 1350 fpm. Power for these motors is supplied by a motor-generator set consisting of three 2500-kw, 700-volt, d-c generators and a flywheel having 185,000 hp-sec of stored energy at 514 rpm, all driven by a 6000-hp, 13,800-volt, wound-rotor, induction motor. The power and speed of this drive, which are unusually high for a mill of this type, were selected to insure fast rolling.

Except for the manipulator finger drives, which are operated under constant potential, all auxiliaries of this mill are operated under adjustable voltage control, including the tables and shear. Power for these drives is provided by four motor-generator sets. Two sets are composed of one 200-kw generator, two 150-kw generators, two 100-kw generators, one 75-kw generator, one 50-kw generator, one 40-kw exciter, and one 1250-hp synchronous motor. The other two sets each include one 250-kw generator, one 75-kw generator, four 40-kw generators, one 25-kw exciter and one 800-hp synchronous motor.

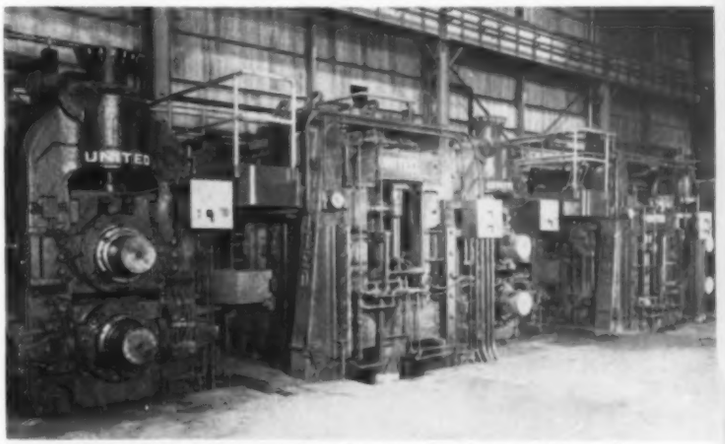
Steel leaving the 40-in. mill proceeds over a table containing a gas scarfing machine equipped with a fume removal system and electrostatic precipitator, and a down-cut shear driven by two 250-hp, 230-volt, d-c motors and capable of cutting sections up to 16 in. x 22 in. and 8 in. x 42 in. This shear has a motor-operated shear gage and a pusher, chute and pit for handling crop ends.

If the steel from the 40-in. mill is to be shipped, it is taken over a 102-ft rope driven, ducking dog type transfer to a parallel table about 34 ft away, where the steel is moved back in the reverse direction, through a down-and-up cut shear with 800,000-lb knife pressure and over two 40 ft x 137 ft 6 in. rope driven, ducking dog type hot beds to screw elevated pilers.

If steel from the 40-in. mill is to be rolled down further, it proceeds straight ahead to a six-stand 30-in. billet mill consisting of three vertical and three horizontal roll stands alternately placed on 10-ft centers. Each stand is individually driven through gearing by a 1750-hp, 300/600-rpm, 600-volt, d-c, shunt motor, which received power from a motor-generator set consisting of four 2000-kw generators driven by an 11,200-hp, 514-rpm, 13,800-volt synchronous motor.

Gear ratios are designed to give mill speeds as follows:

Stand No.	Max roll diam, in.	Gear ratio	Roll rpm	Roll face speed, fpm
1. Vertical	30	15.147	19.8/39.6	155/310
2. Horizontal	32	13.8	21.7/43.4	182/364
3. Vertical	30	12.299	24.4/48.8	183/366
4. Horizontal	32	10.8	27.8/55.6	232/464
5. Vertical	30	8.83	34/68	267/534
6. Horizontal	32	7.321	41/82	343/690



The 30-in. billet mill contains six stands, three with vertical rolls and three with horizontal rolls. Each stand is individually driven by a 1750-hp d-c motor.

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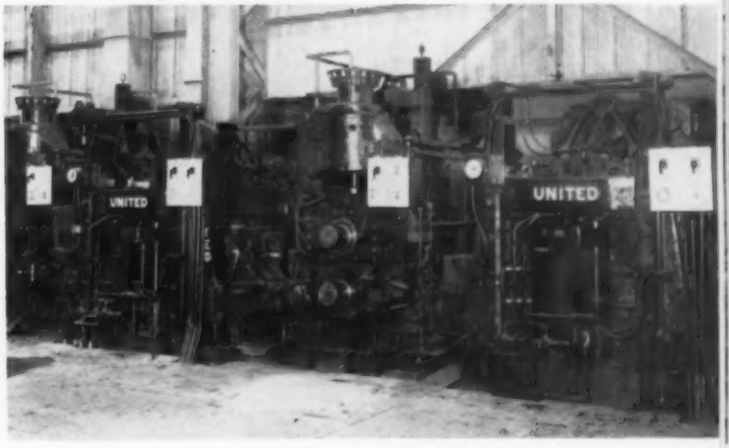
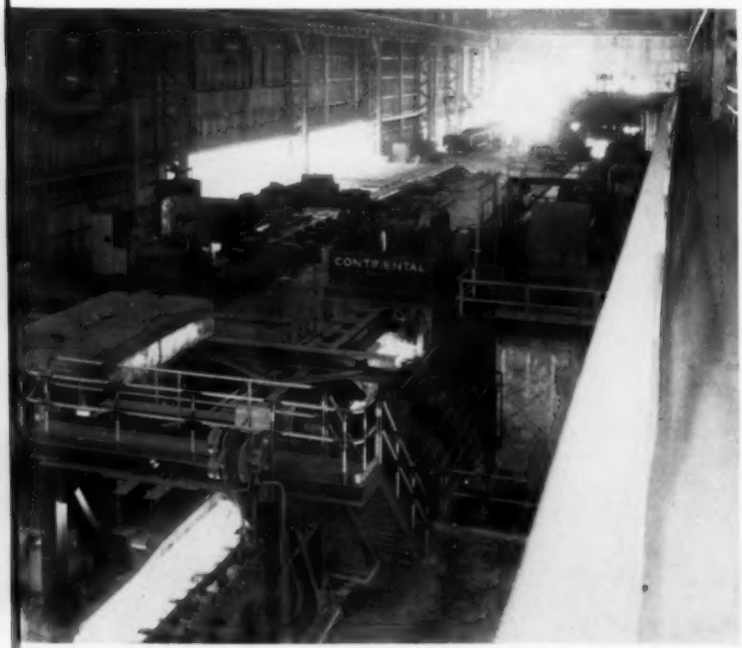
The 21-in. billet mill, similar in design to the 30-in. mill, contains four stands with vertical and horizontal rolls alternating. A 1250-hp d-c motor drives each stand.



A down-cut shear serves the blooming mill and will cut sections up to 16 in. x 22 in. or 8 in. x 42 in.



Mill rolls have a body length of 48 in. and run in roller bearings. Pinion bearings are roller type on the vertical stands and babbitted for the horizontal stands. Roller bearings are applied in the gear reduction sets.

The rolls in each stand are adjusted through the action of 9-in. mill screws of ½ in. pitch driven by a 15-hp motor. The top roll in the horizontal roll stands is balanced hydraulically. In the vertical stands, the rolls are held apart hydraulically.

Vertical roll stands are much like horizontal roll stands laid over on their sides and are capable of the same drafts. The vertical stands, however, are enclosed within outer housing which contain another screw lift mechanism driven by a 35-hp motor so that the entire vertical roll housings may be raised and lowered to align its passes with those of the horizontal roll passes.

Each horizontal roll stand, with its pinion stand and spindle carrier, is mounted as a unit so as to slide endwise on its bed plate, actuated by a hydraulic cylinder. Thus, these stands may be moved to align their roll passes with those of the vertical rolls.

Vertical rolls are driven from the motor and main gear reduction set through a horizontal shaft to an intermediate bevel gear set, through an inclined shaft to a combination bevel gear set and pinion stand.

Steel leaving the 30-in. mill is taken over a 300 ft x 33 ft 10½ in. rope driven transfer to the parallel table previously mentioned. If this product is ready for shipment, it is moved back in the reverse direction through the shear and over the two hot beds described above. If the steel is to be further reduced, it is taken ahead to a swinging crop shear and on to the four-stand, 21-in. mill, generally similar to the 30-in. mill. The 21-in. mill stands are alternately vertical and horizontal, spaced on 8 ft 6 in. centers. Each stand is individually driven by a 1250-hp, 400/800-rpm, 600-volt, d-c, shunt motor. Power for these motors comes from a motor-generator set made up of two 2000-kw generators and a 5600-hp, 514-rpm synchronous motor.

Gear ratios and speeds in the 21-in. mill are as follows:

Stand No.	Max roll diam, in.	Gear ratio	Roll rpm	Roll face speed, fpm
1. Vertical	22	8.2645	48.5/97.0	280/560
2. Horizontal	22	6.8507	58.3/116.6	337/674
3. Vertical	22	5.95	67.1/134.2	387/774
4. Horizontal	22	4.67	85.6/171.2	500/1000

The rolls have a 42-in. body length. Mill screws are 7 in. in diameter and ½ in. pitch, and are driven by a 15-hp motor. As in the 30-in. mill, pass alignment is secured by making the vertical roll stands movable in a vertical direction under the action of 35-hp motors, and the horizontal roll stands movable in a horizontal

The 10-in. bar mill, consisting of 18 stands, reduces billets 2½-4 in. square to small rounds, squares, flats or shapes. Billets are heated in the continuous furnace shown in the background.

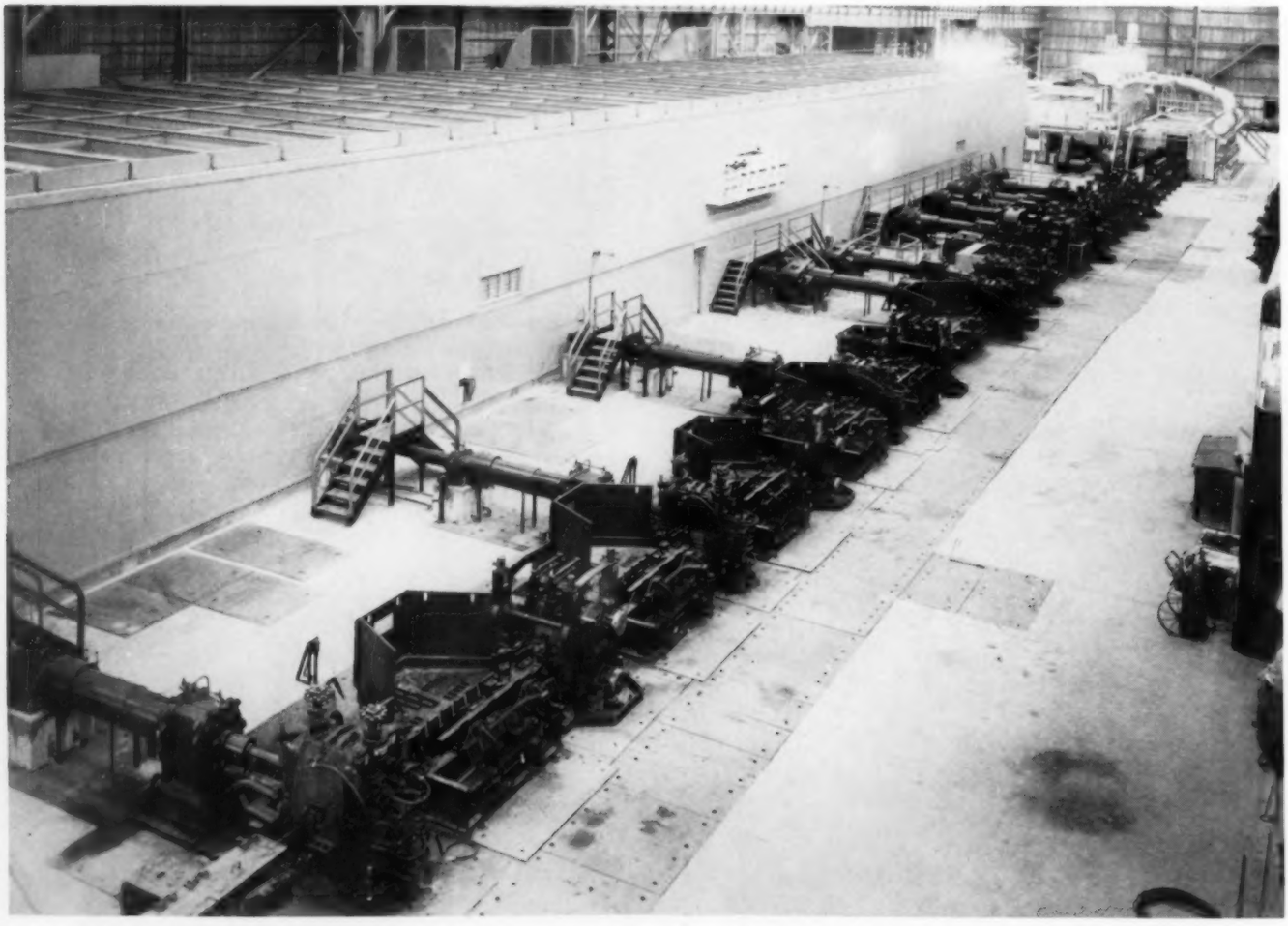


TABLE I
Bar Mill Data

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Motor hp	Motor rpm	Gear ratio	Roll rpm	Roll face speed, fpm
	Maximum diam	Body length						
No. 1 Vertical	15¾	24	.....	400	350/1050	14.2	24.6/73.8	101/303
2 Horizontal	15¾	32	8-4	400	350/1050	12.76	27.4/82.2	113/339
3 Vertical	16⅛	24	8-4	400	350/1050	12.80	27.4/82.2	117/351
4 Horizontal	16⅛	32	8-4	500	125/500	4.552	27.4/109.6	115/460
5 Horizontal	16⅛	32	8-4	500	125/500	3.677	33.9/135.6	143/572
6 Horizontal	16⅛	32	9-0	500	125/500	3.032	41.2/164.8	174/696
7 Vertical	16⅛	24	8-4	600	150/540	2.842	52.8/190	222/802
8 Horizontal	16⅛	32	8-4	600	150/540	2.297	65.4/235	276/992
9 Vertical	13½	20	25-6	600	200/720	2.185	91.5/330	322/1163
10 Horizontal	13½	24	6-9	600	200/720	1.750	114.2/411	404/1450
11 Vertical	13½	20	6-9	600	200/720	1.419	141./506	498/1785
12 Horizontal	13½	24	6-9	600	200/720	1.196	166.6/600	588/2120
13 Vertical	13½	20	23-5	600	200/720	1.098	182/655	644/2310
14 Horizontal	13½	24	15-6	700	200/680	Direct	200/720	707/2400
15 Vertical	11½	21	15-6	700	200/825	0.935	213.5/880	642/2650
16 Horizontal	11½	21	15-6	700	300/960	Direct	300/960	904/2890
17 Vertical	11½	21	15-6	600	400/1150	1.018	392/1127	1183/3390
18 Horizontal	11½	21	15-6	600	400/1150	Direct	400/1150	1205/3460

direction through the action of a hydraulic cylinder. Bearing application is the same as that in the 30-in. mill.

Billets leaving the 21-in. mill pass through an electrically operated flying shear placed 20 ft beyond the last mill stand, over a skewed roller gathering table, and on to four (40 ft x 137 ft 6 in.) rope driven, ducking dog type hot beds.

Separate motor rooms serve the 40-in., 30-in. and 21-in. mills, each provided with down-draft recirculating systems.

The 40-in. mill receives blooms 22 in. x 16 in. or smaller from the 45-in. mill, and rolls them down to minimum 9 in. x 9 in. blooms or 11 in. x 7 in. slabs. The 30-in. mill takes 9 in. x 9 in. blooms or slabs 12 to 18 in. x 5½ to 7 in., and produces billets 4 in. or 5¾ in. square, rounds 4½ to 5¾ in. in diameter, or slabs 10 to 16 in. wide and 3½ to 4 in. thick. The 21-in. mill takes 4-in., 4½-in. or 5¾-in. square or round billets, or 8-in. x 3½-in. slabs and reduces them to 2-in., 2½, 3 or 4-in. squares, 3 to 4½ in. rounds, or slabs 8 to 10 in. wide x 2½ in. thick.

BAR MILL

The 10-in. continuous bar mill takes 2 to 4 in. square billets up to 40 ft long from the billet mill, and reduces them to rounds ⅜ to 2 in. squares 11/32 to 1⅞ in. or hexagons ⅜ to 1⅞ in., angles 1 x 1 in. to 2½ x 2½ in., channels ¾ to 2 in., or flats ⅞ to 5 in. wide. The bar mill building is located at right angle to the other rolling mill buildings, with its billet stock yard near the outlets of the billet mill.

Billets are heated in a triple-fired, side-charge, side-discharge continuous furnace. The sloping hearth is 43 ft wide x 60 ft long. The furnace is fired with mixed gas, with fuel oil as a stand-by, and is equipped with automatic controls for temperature, fuel-air ratio and furnace pressure. A tubular recuperator, containing tubes fabricated of heat resisting metal, is located on the mill floor beside the furnace. The water-cooled skid pipes are insulated about half way back in the heating chamber. Riser and cross-support pipes are also insulated.

The mill itself consists of 18 two-high stands in line, ten with horizontal rolls and eight with vertical rolls. Some details of this mill are set forth in Table I.

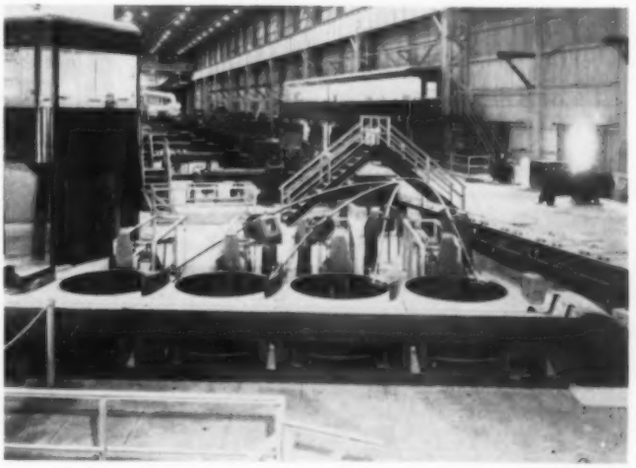
Each stand is individually driven by a 600-volt, d-c motor. Power for the drive motors is furnished by a motor-generator set composed of three 2500-kw generators, one 150-kw exciter and a 10,500-hp, 514-rpm, 13,200-volt synchronous motor.

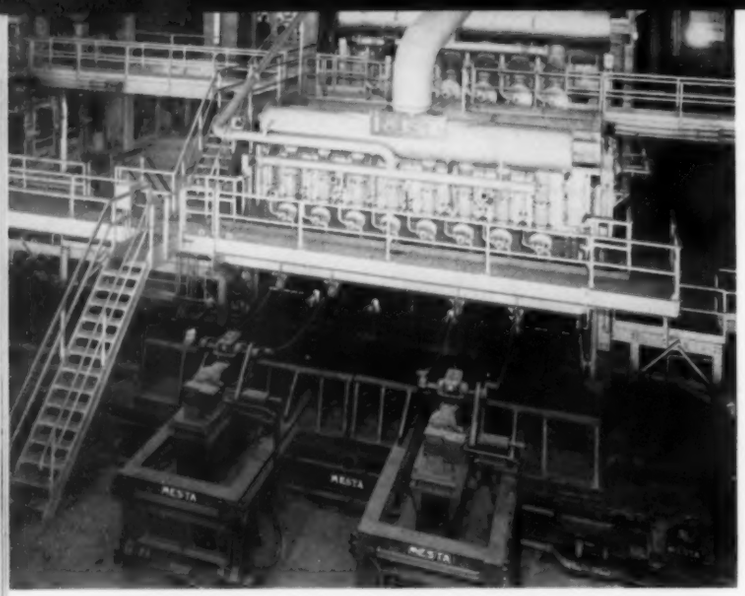
Horizontal and vertical rolls are adjusted by manually operated screws. The vertical lifts of the sliding inner housing assembly of the vertical roll stands are driven by 10-hp, d-c motors through worm and screw drives at a rate of 9⅝ in. per min. All roll necks run in water-lubricated composition bearings.

Steel leaving the bar mill may be directed to four pouring reels or it may proceed straight ahead through a rotary dividing shear and on to a carry-over type double hot bed 420 ft long x 21 ft wide on each side. Coils are moved to a hook type cooling conveyor which makes three parallel runs before unloading the coils in the bar mill warehouse. Material from the hot bed is moved over runout tables, through shears and into cradles located in the warehouse.

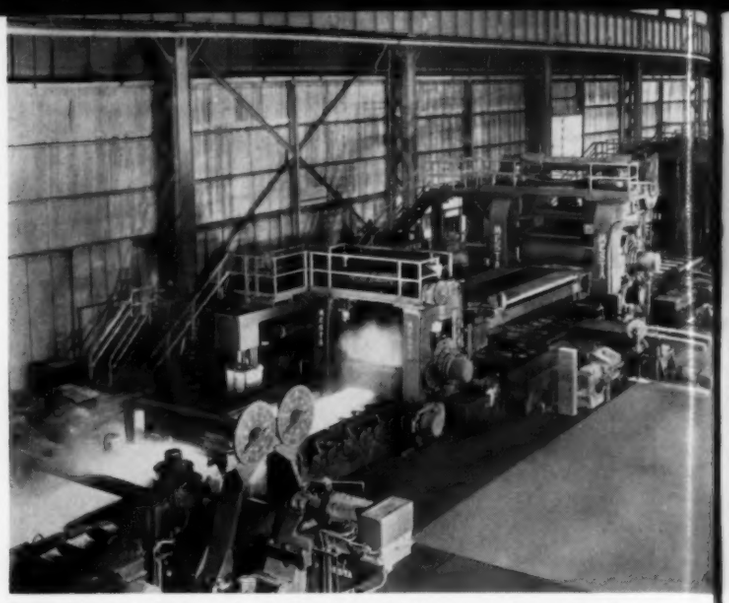
The bar mill warehouse, approximately 325 ft x 485 ft, is arranged in three parallel aisles, and contains

Steel from the bar mill may flow to these pouring reels or it may proceed straight ahead to a double hot bed.





Four continuous triple-fired furnaces of the type shown here heat slabs for the 80-in. strip mill.



Entering the hot strip mill, the slab passes through the vertical edger at the left, then through a two-high scalebreaker and a four-high broadside unit, followed by four universal roughing stands.

shears, grinders, saws, straighteners, scales and other bar finishing equipment, as well as shipping facilities.

Fuel oil is provided by a recirculating system containing two 150,000-gal storage tanks, pumps and heaters, which also supplies the slab furnaces at the hot strip mill. Separate recirculating loops serve the 10-in. mill and the strip mill. A fire foam protection system is installed for this station.

HOT STRIP MILL

The 80-in. hot strip mill, which went into operation in July, 1953, is designed to reduce slabs 16 to 72 in. wide, 4 to 8 in. thick and 7 ft 6 in. to 20 ft long down to strips 18 gauge (0.048 in.) up to a maximum width of 49 in., 16 gauge (0.060 in.) up to 61 in. maximum, and 14 gauge (0.075 in.) up to 74 in. maximum width. All widths can be rolled as heavy as ¼-in. thick and this thickness can be coiled.

Slab storage is provided by a two-aisle building, each aisle 528 ft long x 96 ft wide and containing two 80/20-ton cranes. One aisle also contains a scarfing bed served by two 20-ton semi-gantry cranes. Slabs coming over the transfer from the 45-in. mill table reach the slab furnace charging table and may be moved toward the furnaces for hot charging, or in the opposite direction to a slab transfer car which carries them to the storage and scarfing area.

From storage, slabs are carried by overhead crane on to a magazine unpiler from which a pusher moves them on to the furnace charging table running some 340 ft across the back ends of the furnaces. A double rack-and-pinion type pusher driven by two 75-hp motors moves the slabs in either double or single row from the charging table into and through each furnace.

Heating facilities for the strip mill consist of four continuous triple-fired furnaces. These furnaces have a hearth 96 ft long x 22 ft wide, and are fired with a mixture of natural and coke oven gas, with fuel oil as a stand-by. Each of the three firing zones has individual controls on fuel input and fuel-air ratio, while automatic temperature control is provided for the main heating zone and the soaking zone. Furnace pressure is also automatically controlled.

The furnaces are completely insulated and steel encased. Roofs are of suspended flat arch construction. Air for combustion is supplied by a fan for each furnace, rated at 45,000 cfm. The air is pushed through recuperators made up of relatively small tubes fabricated from sheets of heat resisting alloy, where it is preheated to about 900 F. The recuperators are located above the furnaces, taking advantage of the natural flow of flue gases, which flow directly to the recuperator without dilution. When the firing rate is very low and air temperature approaches a point where the metallic tubes might be damaged, an automatic valve, actuated from the air temperature, opens and bleeds off some of the heated air, thus permitting more air to flow through the recuperator than is needed for combustion.

The heated slabs are expelled from the furnace by the action of the furnace pushers, slide down the chutes to the mill table where spring bumpers absorb the impact. Passing over the furnace and approach tables,

Each universal roughing stand is driven by a 6000-hp synchronous motor and is equipped with integral vertical edging rolls.

TABLE II
Strip Mill Data

Stand	Roll diam, in.		Roll body length, in.	Distance from preceding stand, ft-in.	Motor data				Gear ratio	Roll rpm	Roll face speed, fpm
	Work roll	Back-up roll			Hp	Voltage	Type	Rpm			
Vertical edger	45	.....	32	.....	(2)500	2,300	Wound rotor	505	30.1	16.8	200
No. 1 Scalebreaker	38	.....	80	29-6	2000	13,800	Synchronous	150	7.5	20.	198
Broadside	40	54	130	38-2	3500	13,800	Wound rotor	148	7.67	19.3	201.3
No. 1 Rougher	38	53½	81	55-11	6000	13,800	Synchronous	240	6.5	37.	368
No. 2 Rougher	38	53½	81	77-6	6000	13,800	Synchronous	360	7.5	48.	478
No. 3 Rougher	34	53½	81	116-6	6000	13,800	Synchronous	360	5.71	63.	612
No. 4 Rougher	34	53½	81	188-6	6000	13,800	Synchronous	360	5.71	63.	612
No. 2 Scalebreaker	26	.....	81	274-3	500	600	d-c	300/600	8.364	35.9/71.8	244/488
No. 1 Finisher	27	53½	81	14-8	5000	700	d-c	125/250	4.24	29.4/58.8	207/415
No. 2 Finisher	27	53½	81	18-0	5000	700	d-c	125/250	2.33	53.6/107.2	378/757
No. 3 Finisher	27	53½	81	18-0	5000	700	d-c	80/160	Direct	80/160	565/1130
No. 4 Finisher	27	53½	81	18-0	5000	700	d-c	100/220	Direct	100/220	706/1553
No. 5 Finisher	27	53½	81	18-0	5000	700	d-c	125/270	Direct	125/270	883/1906
No. 6 Finisher	27	53½	81	18-0	4000	700	d-c	150/330	Direct	150/330	1060/2330

which are 310 ft long, the slab comes to the hot strip mill, details of which are given in Table II.

The last four stands of the roughing train are equipped with integral vertical edging rolls, located 6 ft 9 in. in front of the main rolls. These rolls are driven by four 150-hp motors on the first universal stand, one 250-hp motor on the second, and one 200-hp motor on each of the third and fourth stands. The speeds of these motors are controlled to synchronize vertical roll speeds with their respective horizontal rolls. Power for these motors is provided by a four-unit, 2100-kw motor-generator set.

On each side of the broadside mill is a slab turnaround of skew roller type, with alternately tapered table rollers connected to two separate drives. When the drives are run in opposite directions, the slab is pivoted around. Here slabs of lengths not exceeding 10 ft may be turned 90 degrees and rolled crosswise to increase width, then turned back for further rolling. A slab pusher at the entry side of the broadside stand assists in entering slabs between the rolls.

The table following the roughing train is 255 ft long and is driven through line shafts by six 50-hp motors under adjustable voltage control, with power coming from a 400-kw motor-generator set.

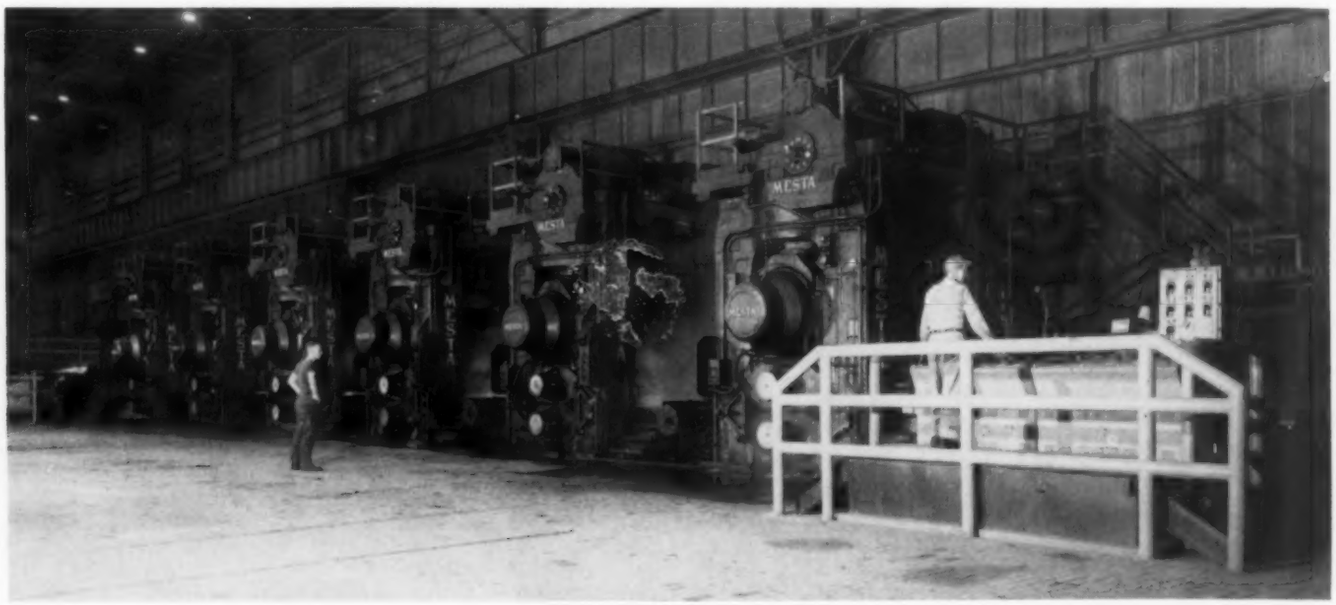
A rotary crop shear, located 10 ft in front of the finishing scalebreaker, is designed to cut sections up to 74 in. wide x 1 in. thick. It is driven by one 150-hp, 230-volt, 460/1150-rpm, d-c motor.

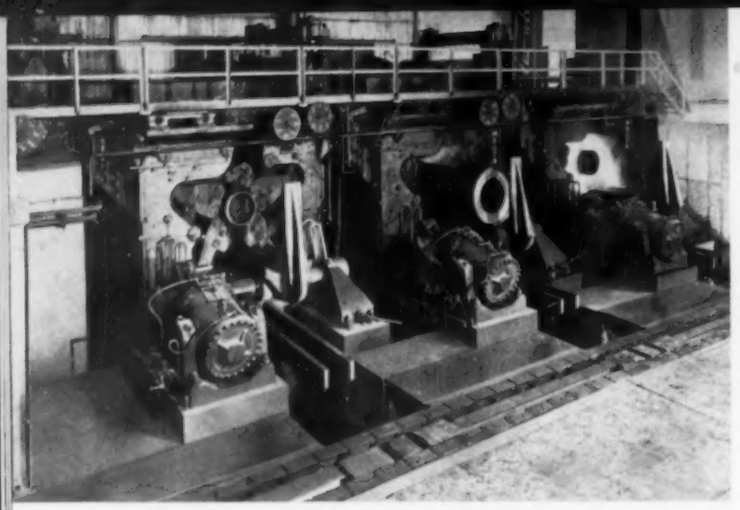
Between the finishing stands are loopers to take up slack in the strip between successive stands. Each looper is operated by a d-c motor which develops 236 ft-lb stall torque. The five motors receive power from a special 40-kw, 75-volt, motor-generator set.

The roughing scalebreaker screws are operated by one 50-hp motor, and the finishing scalebreaker screws by two 10-hp motors. On the rest of the mill, screws on each stand are driven by two 75-hp motors which can be operated individually or, through a magnetic clutch, in unison.

The work rolls of all four-high stands run in roller bearings, while oil film bearings are applied for back-up roll necks. All table rollers are equipped with roller bearings.

The finishing train, with six stands spaced on 18-ft centers, operates with delivery speeds up to 2330 fpm.





Three down coilers with rotating collapsible mandrels form coils up to 60-in. maximum outside diameter, weighing 550 lb per inch of width.

The hot strip motor room is 960 ft long x 65 ft wide. Finishing train drives are shown in the left foreground. Rectifiers and switchgear serving these motors are at the right.

Leaving the finishing train, the strip passes over a runout table 402 ft long to the coilers. Runout table rollers, spaced on 18-in. centers, are individually driven by 267 4-hp, 750-rpm, 250-volt, d-c, shunt motors under adjustable voltage control. Power comes from a motor-generator set made up of three 400-kw generators, one 200-kw generator, one 10-kw exciter and a 1250-hp synchronous motor.

At the end of the runout table are three down coilers with rotating collapsible mandrels. Coils are formed up to a maximum outside diameter of 62 in., weighing 550 lb per inch of width. Each mandrel is driven by a 350-hp, 375/900-rpm, 230-volt, d-c motor, with 25-hp, 700-rpm motors on each of the guide rollers and 200-hp, 420-rpm motors on the pinch rolls. Coiler drives draw power from a motor-generator set duplicating that used for the runout table drive.

All product from the hot mill is coiled and transferred to the raw coil storage department for further processing or shipment.

Thickness of the hot rolled strip is measured by a 100-kv, X-ray gauge with double range for thicknesses of 0.04 to 0.22 in. or 0.22 to 0.40 in.

As an aid in producing good surface on the finished strip, hydraulic descaling sprays are installed ahead of No. 1 scalebreaker, after No. 1, 2 and 3 universal roughing mills, and at No. 2 scalebreaker. Spray valves are pneumatically operated under solenoid control. Water is supplied to the sprays at 1600-psi pressure by three 6-stage, 1250-gpm centrifugal pumps, each driven by a 1500-hp, 3600-rpm, 2300-volt induction motor. Steam jet blowers are also provided at all vertical edging rolls.

As the steel progresses through the mill, its temperature is checked by means of recording radiation pyrometers located on the exit sides of No. 1 scalebreaker and No. 4 rougher, on the entry side of the crop shear, on the exit side of No. 6 finishing stand and just ahead of the coiler pinch rolls.

All main drive motors, gear sets, control equipment and switch gear for the hot mill are located in a motor room 960 ft long x 65 ft wide running beside the hot mill building. Synchronous motors are used for driving the roughing stands with the exception of the vertical edger and the broadside stand, which are driven by wound rotor induction motors. A flywheel is provided for the broadside stand.

Finishing stand motors, operating on adjustable voltage control, receive power from six 4000-kw, 700-volt rectifiers capable of providing rated voltage at twice the rated load. The d-c bus arrangement provides three separate bus sections, each feeding two drive motors and each supplied by two rectifiers in parallel. Rectifier voltage is closely controlled by means of magnetic amplifier voltage regulators. Normally all three d-c bus sections are operated at the same voltage, but transformer taps are provided so that the buses can be operated at different voltages if desired. The finishing scalebreaker drive receives power from a 400-kw, d-c generator.

Coils from the strip mill coilers are ejected on to tilters which set the coils on buggies, and then on to a chain conveyor 1057 ft 6 in. long running through an enclosed conveyor building to the raw coil storage at the sheet and tin mill.

SHEET AND TIN MILL

The sheet and tin mill, with 28 acres of floor space under roof, contains complete facilities for the finishing of hot rolled product and the production of cold rolled sheet and tinplate.

Practically all coils from the hot mill next pass through either of two processing lines: a combination hot-rolled finishing line or a continuous pickling line. Material to be shipped without cold reduction is customarily put through a very unusual 72-in. combination temper pass, side trimming, slitting, recoiling and shearing line. Over 380 ft in length, this line starts with a processing scalebreaker containing two sets of flexing rolls instead of one set, followed by an up-cut shear, pinch rolls, and side trimmer with scrap chopper. When desired, a slitting unit can be put in place of the side trimmer. Next is a two-high 32 in. x 80 in. temper mill with a tension bridle on each side. The mill is driven by a 150-hp, 575/1440-rpm, 230-volt, d-c motor through a gear reduction of 21.5. The entry bridle and pinch rolls are connected to two drag generators of 75-kw and 100-kw capacity, while the exit bridle and pinch rolls are driven by a 100-hp and a 150-hp motor, respectively.

This mill flattens and tempers the material, eliminating an additional handling.

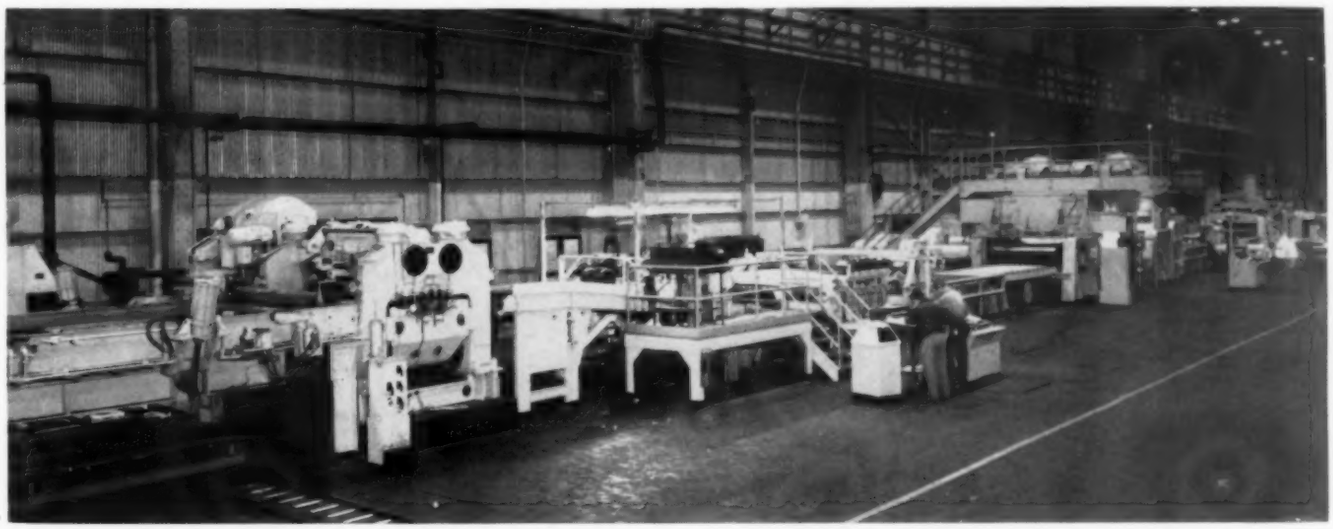
Next in line is a tension reel for coiled product, driven by a 250-hp, 230-volt, d-c motor. Material to be cut to length passes over this coiler on a conveyor and goes through a flying shear, a backed-up roller leveler and a sheet classifier. This last unit, under "electric eye" control, diverts subquality product into a reject piler. The primes pass on through an oiling machine to a lift piler, from which the piles pass over a weighing conveyor section.

This unit is designed for 50,000-lb maximum coil and pack weight, with coils of 28 in. inside diameter and 72 in. maximum outside diameter, and 74 in. maximum width. It will produce edge-trimmed strip of 18-72 in. width, and will handle thicknesses of 0.06 to 0.25 in. (0.125 in. maximum thickness for slitting). Cut-to-length product may range 48 to 288 in. The line operates at speeds of 80/400 fpm.

Coils to be pickled are taken from the raw coil storage building to a continuous 80-in. pickling line 790 ft long. Although following in general the conventional design, this installation contains several innovations which should be mentioned. The first unit in the line is a processing scalebreaker similar to that in the hot rolled finishing line previously described. Next are two crop shears instead of the usual one, the second being installed so that the knives may be kept in top condition for cropping ends to be welded. After the conventional welder, flash trimmer, stitcher, pinch rolls and looping pit comes the unusual installation of a two-high, 32 in. x 80 in. temper mill similar to that used on the 72-in. hot rolled finishing line. The mill effects a reduction of 2 to 5 per cent on the strip and at the same time cracks the hot mill scale so as to improve pickling action. It also improves the shape of the material for subsequent cold rolling.

This mill is driven through a gear reduction set of 7.35 ratio by a 350-hp, 575/1150-rpm, d-c motor.

Next in line are another looping pit and pinch rolls, followed by the pickling tank which is sectionalized into four 84-ft sections. The tank is 10 ft wide, and constructed of welded steel plate lined with rubber and acid-resistant brick. A similar tank 40-ft long contains cold water sprays and a hot water rinse, and is followed by a dryer and a looping pit. Tank covers are of steel construction, lined with rubber and vented to the outside.



This unusual combination hot-rolled finishing line contains a temper mill, side trimmer or slitter, recoiler and shear.

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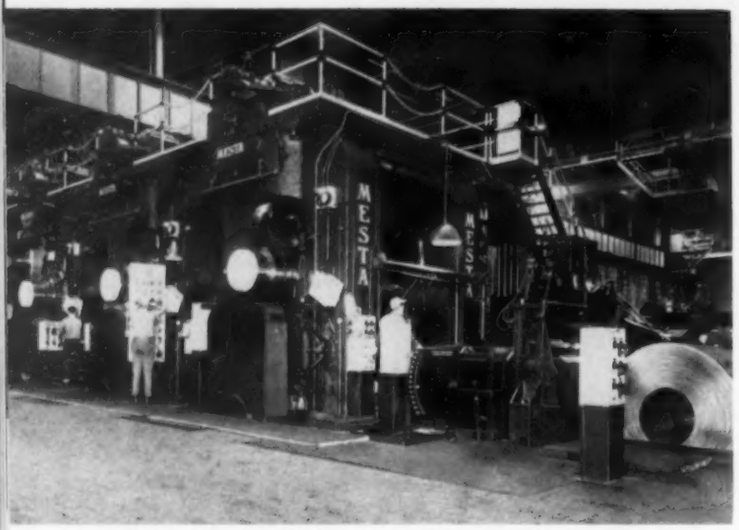
This view shows the exit end of the continuous 80-in. pickling line. The entry end of this unit is unusual in that it contains a temper mill just ahead of the pickling tanks.



This 80-in. four-stand mill produces cold reduced sheets. It is designed for a top delivery speed of 3100 fpm.

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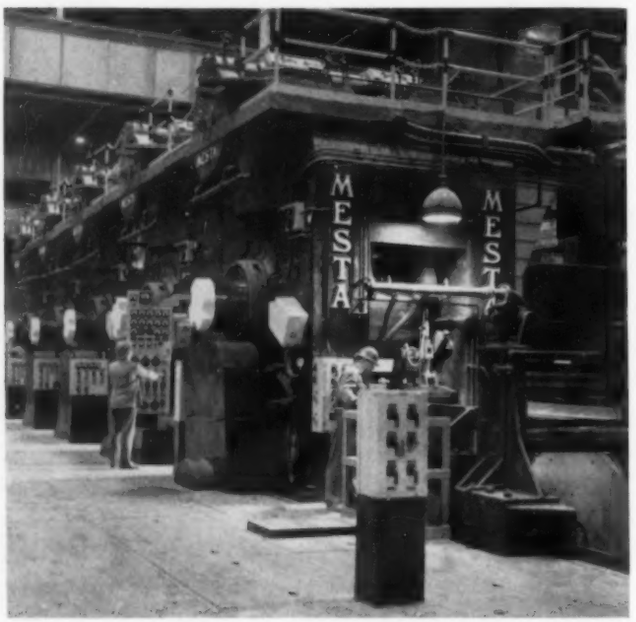
Tinplate is cold reduced on this five-stand 48-in. mill at speeds up to 7000 fpm. Main drives total 20,250 hp.



Pumps are installed to circulate and reclaim the acid-contaminated water from the rinse tank, discharging it into the pickling tank. The pickling solution, which is heated by steam with the temperature automatically controlled, cascades back from the exit end over the dividing baffles between the four tank sections and is drawn off from a single outlet at the entry end.

At the exit end of the line are a shear, a side trimmer with scrap chopper, a tension bridle, an oiling machine, a tension reel and an upcoiler. The 24-in. tension reel generally used for material to be shipped as hot rolled, pickled product.

The line is designed for material 18 to 74 in. wide and 0.06 to 0.25 in. thick, taking coils 24 to 28 in. inside diameter, up to 72 in. outside diameter and up to 30,000-lb weight. Exit coils for cold reduction are 16 to 18 in. inside diameter, up to 72 in. outside diameter and up to 50,000 lb weight. The line operates at speeds up to 600 fpm (1500 fpm for entry end).

Pickled coils are carried on a conveyor to a storage area serving the cold reduction mills, where they are handled by overhead crane. Pallet-type conveyors subsequently move the coils to the cold mills.

Cold reduced sheets are rolled on a four-stand, 80-in. mill designed for a top delivery speed of 3110 fpm. The stands are spaced on 15-ft centers, and use 21 in. x 80 in. forged steel work rolls and 56 in. x 75 in. cast steel back-up rolls. Roller bearings are applied to the work rolls and oil-film bearings to back-up rolls. Screwdowns on each stand are driven by two 100-hp, d-c motors, connected by a magnetic clutch.

The first stand is driven by a 3000-hp, single-armature motor, the second by a 6000-hp, double-armature motor, the third by a 6000-hp, triple-armature motor, and the fourth by a 5250-hp, triple-armature motor, all of 750 volts. The overhung collapsible mandrel reel is driven by a 1400-hp motor with 325-volt double armatures in series.

Two motor-generator sets serve these drive motors. One of these sets carries three 2400-kw generators (one for No. 1 stand motor and two for No. 2 stand motor), a 150-kw exciter, and a 10,500-hp, 514-rpm, 13,200-volt synchronous motor. The second set consists of four 2400-kw generators (two for No. 3 stand and two for No. 4 stand), a 1200-kw generator for the reel, a 150-kw exciter, and a 15,000-hp, 514-rpm, 13,200-volt synchronous motor.

Speeds in this mill are as follows:

Stand	Motor rpm	Gear ratio	Roll rpm	Roll face speed, fpm
1	90/270	1	90/270	495/1485
2	150/350	1	150/350	825/1910
3	200/500	1	200/500	1100/2750
4	250/565	1	250/565	1375/3110
Reel	150/525	.	.....	945/3300

Three indicating tensiometers are installed between the stands, and a double range X-ray gauge measures

Cold reduced sheet and some tinplate material are annealed in eleven portable cover furnaces. Each furnace accommodates four stacks of coils with a total weight of 625,000 lb.

strip thicknesses of 0.006 to 0.048 in., and 0.048 to 0.088 in. at the mill exit.

Tinplate is rolled on the five-stand cold reduction mill, which began operations in December, 1952. It consists of five 4-high stands spaced on 13 ft 8 in. centers. Forged steel work rolls are 21 in. x 48 in., and cast steel back up rolls 53 in. x 48 in. Roller bearings are used for work rolls, and oil film bearings for back-up rolls. Two 75-hp motors on each stand operate the mill screws. In order to secure rapid response and fine adjustment, these screwdown drives are controlled by adjustable voltage, with a motor-generator set carrying a 75-kw generator for each pair of motors.

The first mill stand is driven by a 1750-hp, single-armature motor, the second by a 3500-hp, double-armature motor, the third by two 2250-hp, single-armature motors in a twin drive arrangement, the fourth by two 2250-hp, double-armature motors in twin drive, and the fifth stand by two 3000-hp, triple-armature motors in twin drive. All of these motors are 750 volts, as is the 1400-hp, double-armature motor which drives the reel.

These drives draw power from two motor-generator sets. One set consists of a 2800-kw generator for No. 2 stand motor, two 3600-kw generators (one for No. 3 stand, one for No. 4 stand) and a 150-kw exciter, all driven by a 14,000-hp, 360-rpm, 13,200-volt synchronous motor. The second set is made up of a 1400-kw generator for No. 1 stand, two 2400-kw generators for No. 5 stand, a 1200-kw unit for the reel drive, a 150-kw exciter, and a 10,500-hp, 514-rpm, 13,200-volt synchronous motor.

Coil entering equipment on this mill is designed to handle coils 16 to 18 in. inside diameter and up to 78 in. outside diameter, weighing up to 1050 lb per inch of width with a maximum weight of 36,000 lb per coil.

Speeds of these stands are as follows:

Stand	Motor rpm	Gear ratio	Roll rpm	Roll face speed, fpm
1	110/310	1.0	110/310	606/1702
2	165/420	1.0	168/420	925/2310
3	200/415	1.51	302/627	1660/3450
4	300/625	1.51	453/944	2490/5200
5	345/635	2.0	690/1270	3790/7000
Reel	350/1700	1	.....	1510/7340

The gear sets on the last three stands are step-up units increasing the mill speed instead of reducing it.

This mill is also equipped with an indicating tensiometer between each successive pair of stands, and a 50-kv X-ray gauge, capable of measuring thicknesses from 0.006 to 0.04 in. at the mill exit.

It should be noted that all of the cold mills are designed with drives which present low inertia, so as to obtain quick response and rapid acceleration and deceleration. This aids in reducing the amount of off-gauge material.

Cold rolled material that is to be batch annealed may be processed as an optional treatment through a 56-in. electrolytic cleaning line which operates at speeds up to 2000 fpm and handles coils up to 48 in. wide and 50,000 lb in weight. In general, it is of conventional design, with pay-off reel, welder, a 93-ft electrolytic caustic tank, a scrubber, spray tank and dryer, a tension bridle, a shear, a scanning head and a tension reel. The tank is covered and equipped with a fume exhaust system. An electronic edge regulator is used on the tension reel to wind a straight edged coil.

Annealing facilities include 11 portable cover type furnaces and one 48-in. continuous annealing line. The cover type furnaces, 37 ft 8 in. long x 11 ft 9½ in. wide x 18 ft 11¾ in. high, operate on 27 bases and are heated by natural gas, coke oven gas, or a combination of both burned in radiant tubes, with gas and air proportioned and mixed by a carburetor on each furnace. Exhaust gases are collected at each furnace by a centrifugal blower and removed from the building.

Each furnace accommodates four stacks of coils with a total weight of 625,000 lb. Each stack is protected by a cylindrical inner cover. The bases are designed for the circulation of gas within the inner covers by means of a fan.

The cooling cycle is speeded up by the introduction of air from the basement blowing on the inner covers. This air is provided by 18 axial flow fans with a total capacity of 605,700 cfm.

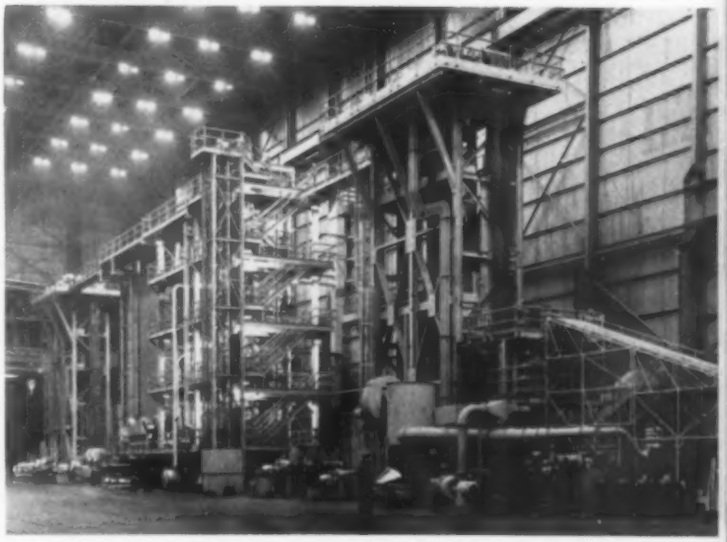
Automatic temperature controls are mounted on each cover, and coil temperatures are recorded in a central control room.

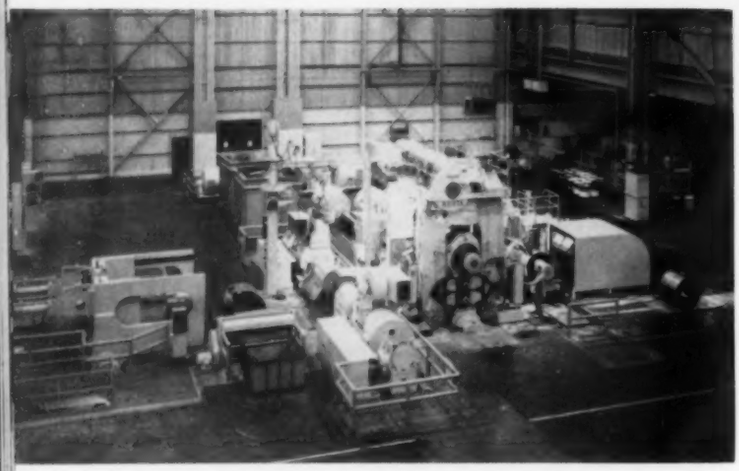
The batch anneal furnaces are used for annealing sheet material and some tinplate material.

The balance of the tinplate material is annealed in a continuous annealing line. This unit is very similar to that installed at the corporation's Gary sheet and tin mill. It is 385 ft long on the floor, but numerous vertical passes accommodate approximately 3000 ft of strip between the two ends.

Two pay-off reels, a shear, a seam welder and a looping pit combine to feed a continuous strip into the unit, the first part of which is an electrolytic cleaner, scrubber and rinser. The line contains six vertical heating passes heated by gas fired radiant tubes where the strip is brought to about 1200 F, six vertical soaking passes, electrically heated, two slow cooling passes where temperature is controlled by electric heating elements or air-cooled tubes as required to reduce strip temperature to 900 F, and 20 fast cooling passes with water

The continuous annealing line, which contains an electrolytic cleaner and scrubber, operates at speeds up to 1000 fpm.





Sheet temper rolling is performed in this single stand 80-in. mill. It is driven by two 600-hp motors in twin drive arrangement, and is designed for a maximum speed of 3500 fpm.

cooled tubes to lower strip temperature to about 250 F. Air jets at the exit further reduce the strip temperature. Deoxidizing gas, containing principally nitrogen with 3-6 per cent hydrogen, is supplied to the furnace zones, imparting a bright finish. This gas is prepared in two 20,000-cfhr machines which also supply the batch annealing furnaces.

The entire line operates under automatic control at speeds up to 1000 fpm.

Sheet temper rolling is done in a single four-high stand designed for strip 18 to 72 in. wide and 0.0239 to 0.075 in. thick. Work rolls, 20 in. x 80 in., run in roller bearings, while back-up rolls, 53 in. x 81 in., operate in oil film bearings. Each work roll is driven by a 600-hp, 250/720-rpm, 600-volt, single-armature d-c motor in a twin-drive arrangement containing off-setting gears. These motors are provided with special fields to provide load balance through a rotating regulator.

The cone type feed reel is equipped with two 300-kw, 175/650-rpm drag generators which operate in parallel and have special fields for load balance with a rotating regulator. A counter-emf regulator is used for drag generator fields to compensate for coil diameter decrease. Coil entering equipment is designed to handle coils up to 72 in. outside diameter, 16½ or 24 in. inside diameter, and up to 50,000-lb weight.

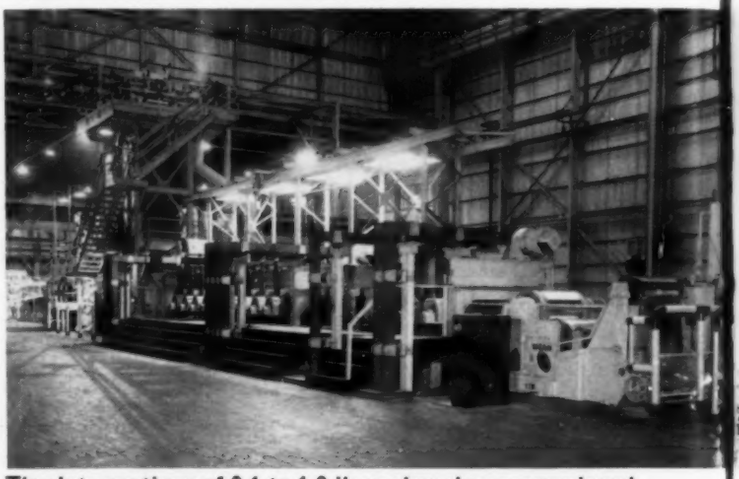
The tension reel, with a 24-in. diameter expanding mandrel, is equipped with a hydraulically operated belt wrapper and is driven by a 1600-hp, 175/650-rpm, double-armature, d-c motor. The two armatures operate in parallel, with loads balanced by special fields and a rotating regulator. Counter-emf and current regulators compensate for coil build-up and control tension.

The drive motors of this mill are served by a four-unit set consisting of one 1250-kw generator for the roll drives, one 1250-kw generator for the tension reel motor and one 600-kw generator which supplies power or absorbs it from the feed reel drag generators, all driven by a 3500-hp synchronous motor.

The mill is designed to operate at speeds as high as 3500 fpm.

Miscellaneous sheet finishing equipment includes the following:

One 80-in. sheet recoil line for side trimming, stenciling and oiling. Maximum speed, 1250 fpm.



Tinplate coatings of 0.1 to 1.0 lb per base box are produced on this electrolytic tinning line, which operates at speeds up to 1250 fpm.

One 80-in. sheet shear line for side trimming, stenciling, oiling and cutting to length. Maximum speed is 1250 fpm.

One 56-in. sheet shear line for side trimming, stenciling, oiling and cutting to length. Maximum speed is 1250 fpm.

One 182-in. resquaring shear.

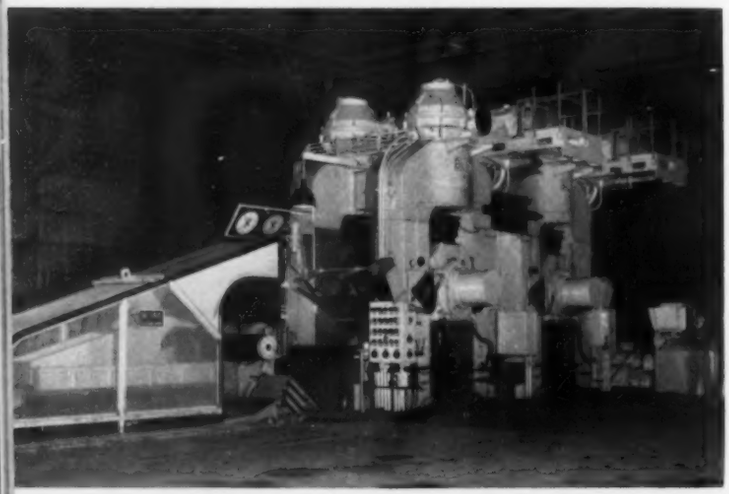
One stretcher leveler.

Tinplate material is temper rolled in a two-stand, four high, 19 in. and 53 in. x 48 in. tandem mill having a top speed of 3700 fpm. The first stand is driven by two 300-hp, 575/750-rpm, double-armature motors, and the second stand by two 400-hp, 575/750-rpm, double-armature motors, all in twin drive arrangements. Coils are fed to the mill by a cone type pay-off reel equipped with two 150-kw, d-c drag generators. Leaving the mill, the strip passes through tension rolls, driven by three 200-hp motors, and on to a tension reel driven by two 200-hp motors.

These drive motors receive power from a two-unit, 1600-kw motor-generator set for the main drives and a seven-unit, 893-kw set for the reel and booster.

The mill is equipped with pressure gauges, an extensometer, and a tensiometer.

Tinplate material is temper rolled on this two-stand 48-in. mill at speeds up to 3700 fpm.



Miscellaneous tinplate finishing equipment includes the following:

One 40-in. tin recoil line for side trimming. Maximum speed is 400 fpm.

One 40-in. tin shear line for side trimming and cutting to length. Maximum speed is 1250 fpm.

The electrolytic tinning line is similar to those installed in other plants of the corporation. It is 312 ft long over-all, and begins with two pay-off coil holders, a double-cut shear, a welder, pinch rolls, looping pit and entry bridle. The cleaning section of the unit contains six vertical tanks, and the plating section, seven. Plating current runs about 90,000 amperes at 15 volts.

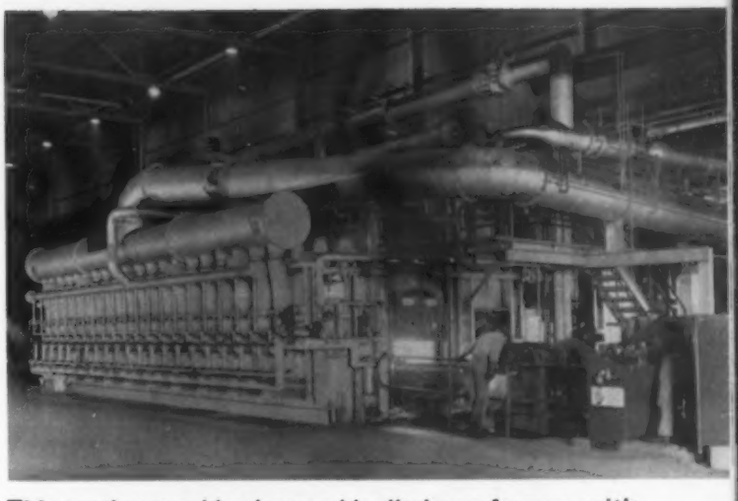
Emerging from the plating section, the strip passes through a reflow unit designed for electrical resistance heating, chemical treating tanks, an electrostatic oiler, a pin hole detector, a drive bridle, a rotary flying shear and a sheet classifier. Here the sheared tinplate is automatically separated into four piles: wasters, menders, and two prime piles.

This line can produce coatings ranging 0.1 to 1.0 lb per base box and has a top speed of 1250 fpm.

Located near the electro-tinning line is an assorting line which receives packs of tinplate 15 to 38 in. wide and 20 to 43 in. long. This line consists of an entry pack conveyor, a sheet feeder, inspection belt conveyor, a reject piler and by-pass conveyor with double throw-out device, lapping conveyor and mender piler, a prime piler, runout conveyor, a scale and a packaging elevator.

A portion of the electro-tinned product is put through this line, which delivers sheets in prime packs up to 27 in. high or 10,000 lb maximum weight. The inspection and by-pass conveyors operate in a speed range of 150-600 fpm, while the lapping conveyor runs at 50-200 fpm.

For heavier coatings, cut-to-length material is put through five hot-dip lines, designed for line assorting. These lines operate at speeds up to 200-500 in. per minute. Each line includes entry conveyors and feeders, electrolytic pickler, tinning machine and pot, wet washer, dry cleaner, inspection conveyor, pilers for rejects, menders and primes, a scale and a packaging elevator. The inspecting, assorting and packaging section runs at 25-200 fpm.



This continuous side-charge, side-discharge furnace, with hearth 43 ft wide x 60 ft long, heats slabs for the skelp mill at National Tube Division.

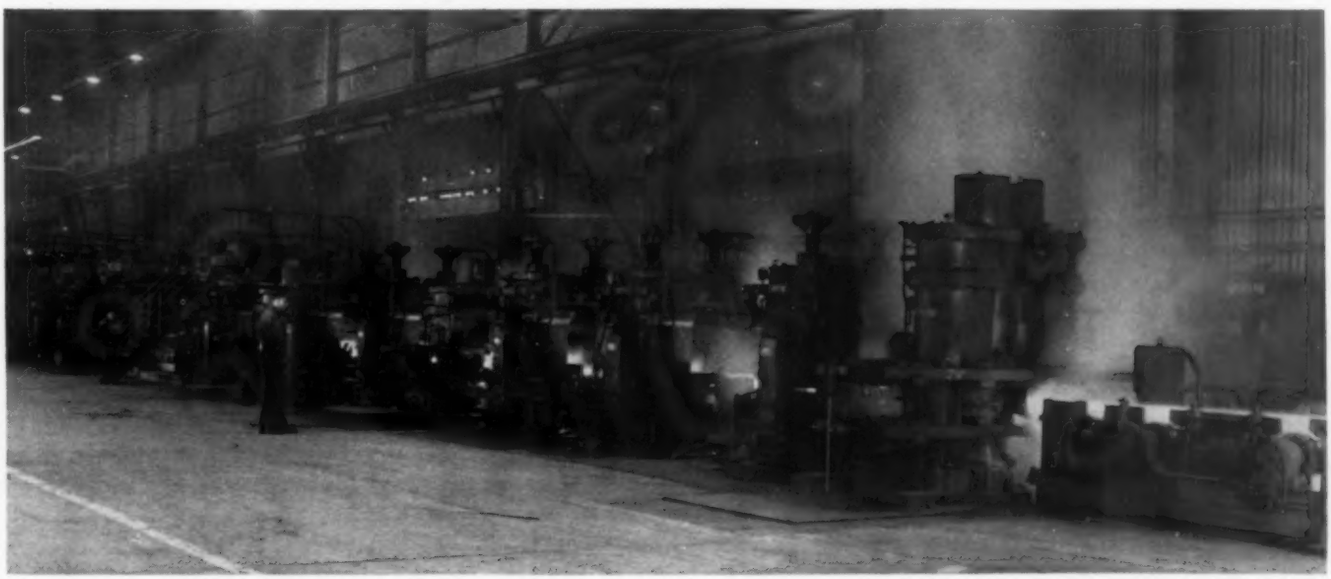
The lines will take black plate 0.006 to 0.025 in. thick, 15 to 38 in. wide and 18 to 43 in. long in packs up to 54 in. high or 25,000 lb. They deliver packs up to 27 in. high or 10,000 lb.

NATIONAL TUBE DIVISION

The National Tube plant at Fairless Works has 20 acres under roof and at present consists primarily of a skelp mill, two butt-weld tube mills and auxiliary finishing equipment, providing facilities for the production of ½ to 4 in. diameter butt-weld pipe.

Steel slabs, 7 to 16 in. wide, 3½ to 4 in. thick, 32 to 40 ft long and 2670 to 9790 lb in weight, come to the division from the blooming or billet mills. The slabs are heated in a continuous side-charge, side-discharge furnace with a solid sloping hearth 43 ft wide x 60 ft long. It is fired in a two-zone arrangement by mixed gas, with fuel oil as a stand-by. A refractory tile recuperator is located beneath the furnace, and waste gases are removed by a 150-ft stack. Automatic controls are pro-

The 18-in. skelp mill, consisting of ten horizontal roll stands and five vertical edgers, delivers skelp at speeds up to 1382 fpm.



vided for furnace temperature, fuel-air ratio and furnace pressure.

Slabs are charged to the furnace by means of a slab unscrambler, charging conveyor and buggy, and pusher. A push-out bar and pull-out rolls remove heated slabs from the furnace.

The skelp mill is an 18-in. continuous train with ten horizontal two-high roll stands and five edging stands. Some details of this mill are given in Table III.

Alloy steel rolls are used in all edgers and roughing stands, while finishing stands use chilled iron and alloy grain rolls. The rolls are adjusted by mill screws 6 in. in diameter on horizontal stands and 3, 3½ or 4 in. diameter on edgers, all of ¼ in. pitch. Maximum openings between rolls are 3½ in. on horizontal rolls, 34 in. and 25¾ in. on edgers. Edging rolls are adjusted sideways by hydraulic mechanisms and hand operated screws, while their vertical adjustment is effected by manual screws which operate wedges. Screws on the horizontal stands are manually operated on the first five stands, and by a 15-hp, d-c motor on each of the last five stands. All bottom rolls are adjusted by manual screws which operate wedges. Edgers are equipped with sleeve bearings, with oil film bearings on the horizontal roll necks.

The mill is driven by variable speed 600/450 volt, d-c motors as enumerated in Table III. Power is supplied by two 3000-kw rectifiers. D-c auxiliaries receive power from two 1000-kw rectifiers.

Ahead of the first three stands are top and bottom hydraulic descaling sprays to which water is supplied at 1500 psi. The mill and its auxiliaries are lubricated by seven circulating oil systems with continuous filtering systems and fifteen automatic grease systems.

Skelp leaving the mill travels over an 85-ft runout table with rollers individually driven by variable frequency alternating current. Horizontal pinch rolls at the end of this table pull the strip from the table into a trough that twists the skelp into a vertical position. About 10 ft beyond the trough, a switch guides the skelp alternately to one of two apron conveyors. At the head of each conveyor is a vibrator which oscillates through a 60-degree arc, delivering the skelp on to the conveyor on edge in serpentine form. At the end of each conveyor is a vertical crop shear, and a reel with 20-in. mandrel and a size range of 36 to 56 in. outside diameter coils.

THOMAS C. BEATTIE
General Superintendent
National Tube Division

Skelp is formed into butt-weld pipe in two continuous mill lines, one designed for ½ to 1½ in. pipe, one for 1¼ to 4 in. pipe. For the small sizes, skelp ranges 6¾ to 16 in. in width, 0.103 to 0.200 in. in thickness, and 850 to 1390 ft long. For the larger sizes, the skelp runs 11 to 18 in. wide, 0.121 to 0.337 in. thick and 500 to 1200 ft long. The two mills are quite similar, with the charging end including a coil pusher, an uncoiler for 60-in. maximum outside diameter coils 6 to 18 in. wide, a roller leveler, double up-cut shear, flash welder, pinch rolls, magnet rolls, loop control and furnace threader.

Each mill line contains a skelp heating furnace, 154

TABLE III
Skelp Mill Data

Stand	Diameter, in.	Body length, in.	Distance from preceding stand, ft-in.	Motor hp	Motor rpm	Gear ratio	Roll rpm	Roll face speed, fpm
No. 1 Edger	15.000/12.500	12	....	200	225/1200	51.632	4.36/23.24	14/91
No. 1 Rougher	19.063/17.313	22	7-9	600	225/900	3.913	6.64/26.54	30/132
No. 2 Rougher	19.063/17.313	22	10-6	600	225/900	25.517	8.82/35.27	40/176
No. 3 Rougher	19.625/17/875	22	10-0	800	262/875	17.676	14.85/49.50	70/254
No. 2 Edger	12.000/9.000	7	8-6	150	225/1200	9.533	23.60/125.88	56/396
No. 4 Rougher	19.875/18.125	22	7-6	800	262/875	11.555	22.72/75.73	108/394
No. 5 Rougher	20.063/18.313	22	11-0	800	262/875	7.846	33.46/111.52	160/586
No. 3 Edger	11.000/9.000	7	7-0	150	225/1200	4.807	46.81/249.64	110/719
No. 6 Finisher	18.938/17.188	22	9-0	800	262/875	5.690	46.13/153.78	208/762
No. 7 Finisher	19.063/17.313	22	27-0	800	262/875	4.735	55.44/184.79	251/922
No. 4 Edger	13.000/12.000	4	7-0	150	225/1200	3.668	61.34/327.15	193/1113
No. 8 Finisher	19.125/17.375	22	9-0	800	262/875	4.067	64.54/215.15	294/1077
No. 9 Finisher	19.125/17.375	22	10-0	800	262/875	3.542	74.11/247.04	337/1237
No. 5 Edger	13.000/12.000	4	7-0	150	225/1200	2.849	78.98/421.20	248/1433
No. 10 Finisher	19.250/17/500	22	9-0	800	262/875	3.192	82.24/274.12	377/1382

C. I. WILSON
Superintendent
Skelp Mill

M. G. MORGAN
Superintendent, Continuous
Weld Mill & Galvanize

S. ANDREWS
Chief Engineer

P. L. DOLAN
Superintendent
Maintenance

P. P. CHAPLA
Superintendent, Finishing,
Stocking & Shipping

M. I. SHEA
Chief of
Production Planning

W. L. BROWN
Assistant to
General Superintendent

F. H. JOHNSON
Superintendent
Metallurgical & Inspection

C. V. PROVINCE
Manager of
Industrial Relations

E. H. JENNESS
Chief Plant
Industrial Engineer

W. H. DENGLER
Works Auditor

W. G. CARLSON
Chief of Stores

ft long x 33 in. wide, three-zone, for the smaller mill and 172 ft long x 36 in. wide, four-zone, for the larger mill. The recuperative furnaces are fired with mixed gas or fuel oil and are equipped with automatic controls.

Each pipe mill consists of a six-stand forming and welding mill spaced on 2 ft 3 in. centers, followed at a distance of 53 ft 8½ in. by a reducing mill of ten stands for the smaller mill and eight stands for the larger sizes. The reducing stands are also spaced on 2 ft 3 in. centers. On each mill, a three-stand sizing mill, with stands spaced on 3 ft 8 in. centers, is located 44 ft beyond the end of the reducing train.

In both mills, the first forming stands use rolls 13½ to 14 in. in diameter x 9¾ in. face. All other forming, welding and reducing stands use rolls 13½ to 14 in. diameter x 7½ in. face. Sizing stand rolls are 14 to 16 in. in diameter x 6½ in. face. All rolls are of alloyed cast iron.

Each mill stand is individually driven through gears and pinions by 450/1800-rpm, 2300-volt, d-c motors. Motor horsepower, gear ratios and roll speeds are as given in Table IV. No. 1 mill is designed with maximum speeds of 990 fpm in the forming and welding mill, and 1250 fpm for the reducing and sizing mills. In No.

TABLE IV
Butt-Weld Pipe Mill Data

Stand No.	No. 1 Mill			No. 2 Mill		
	Motor hp	Gear ratio	Roll rpm	Motor hp	Gear ratio	Roll rpm
1	25	14.080	31.96/127.84	25	18.6476	24.13/96.52
2	25	11.415	39.42/157.69	25	14.6842	30.65/122.58
3	25	10.749	41.86/167.45	25	13.7950	32.62/130.48
4	25	9.5917	46.92/187.66	25	12.9905	34.64/138.56
5	25	9.0647	49.64/198.57	25	12.2590	36.71/146.83
6	25	8.5361	52.72/210.87	25	11.5913	38.82/155.29
7	75	8.0566	55.86/223.44	100	11.4150	39.42/157.68
8	75	7.2273	62.26/249.05	100	9.5917	46.91/187.64
9	100	6.6076	67.98/271.90	100	9.0647	49.64/198.56
10	100	5.8719	77.05/308.22	100	8.0556	55.86/223.44
11	100	5.5520	81.97/327.87	125	7.2273	62.26/249.05
12	100	5.0416	88.93/355.73	125	6.6076	68.10/272.41
13	125	4.5384	98.90/395.60	125	5.8719	76.64/306.54
14	125	4.0961	110.02/440.10	125	5.5520	81.05/324.20
15	125	3.7044	121.95/487.80	50	10.	45/180
16	125	3.3550	133.14/532.54	50	10.	45/180
17	50	5.1	90/360	50	10.	45/180
18	50	5.1	90/360			
19	50	5.1	90/360			

Skelp is discharged on to apron conveyors by oscillating vibrators, forming the serpentine pattern shown here. The skelp is then moved to coilers.

2 mill, maximum speeds are 450 fpm in the forming and welding mill and 650 fpm in the reducing and sizing stands.

The mill drives, as well as those of the auxiliaries, are all synchronized, and receive power from a 1000-kw motor-generator set for each mill.

All gearing, pinions and mill stands are equipped with roller bearings.

Coils of skelp are placed in the uncoiler, fed into the leveler, cropped and put into the flash welder which joins successive coils into one continuous strip. On No. 1 mill, the welder is a 500-kva unit; on No. 2, a 750-kva unit. Leaving the welder, skelp forms a loop about 160 ft long on the mill floor, providing storage so the skelp flows through the furnace continuously during stops at the welder.

As skelp leaves the furnace it enters the first mill stand which forms it into more or less a horseshoe shape, with the opening down. A welding horn located immediately after this stand has a lip which enters the opening of the curved shape to prevent twisting. The tip of the horn is drilled to permit jets of air or oxygen to impinge on the edges of the skelp.

The actual welding takes place in No. 2 stand, where the rolls bring the skelp edges together under pressure. The remaining stands of the mill reduce the diameter of the pipe. The axes of the rolls in each stand are at right angles to those in the preceding stand in order to maintain roundness. The reduction in each stand varies from about 7.5 per cent for ½ in. pipe to 3 per cent for 4 in. pipe.

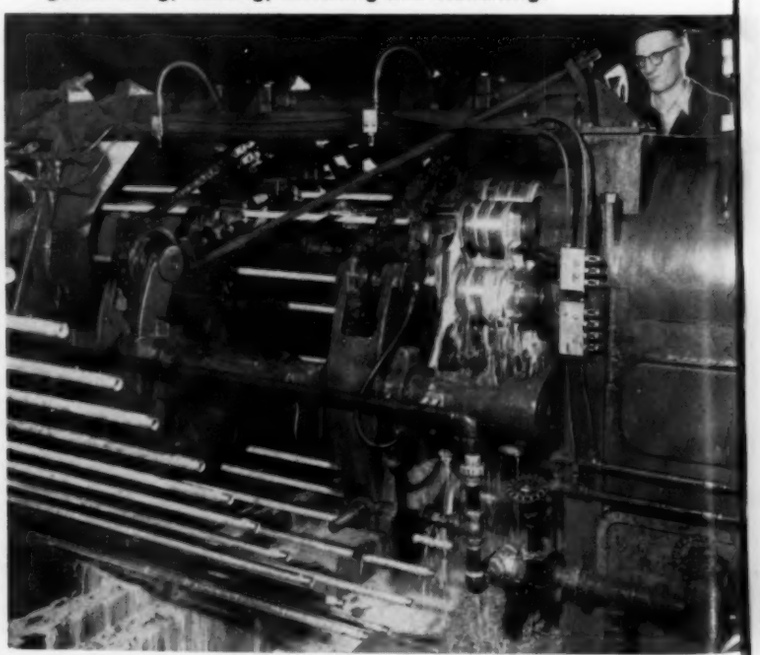
The reducing stands in both mills are set up to use the stretch reducing process introduced by the corporation in all the pipe mills it has installed in recent years. Each successive stand runs at a somewhat higher speed than would be called for by the normal reduction in each pass, so that the tube is under tension through all of the stands. This process makes possible the use of fewer skelp sizes for the range of pipe sizes.

The formed pipe, in a continuous length, passes on to the three-stand sizing mill, where it is given a slight reduction in outside diameter to meet size tolerances and to remove mill scale.

A rotary hot saw about 24 in. in diameter at the exit of the sizing mill cuts the continuous tube into desired length. The saw is designed for three cutting ranges of 18 to 27 ft, 27 to 40.5 ft or 36 to 54 ft.

Butt weld pipe is made in two continuous mills, one designed for ½-1½ in. diameters, the other for 1½-4 in. diameters.

Complete facilities for pipe finishing are provided, including facing, threading, coupling, hydrostatic testing, galvanizing, coating, bundling and stenciling.

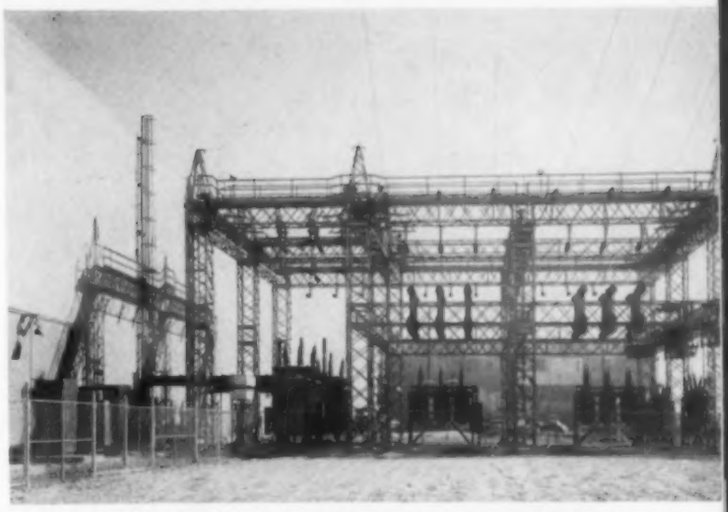


From the saw, the cut pipe is conveyed to a screw type kick-out which puts the pipe on to a hot straightener and cooling bed. This unit is designed as two screw-type cooling beds with the straightener between. A cropping saw about 40 in. in diameter is located on each side of the bed.

As pipe leaves the cooling bed, it drops into a water bosh tank. After being cooled, the pipe passes over another screw conveyor which contains saw for cutting the length into two pieces if desired. On No. 2 mill, inspection is performed on the transfer immediately after the saw. On No. 1 mill, a chain transfer carries the pipe to an adjoining building for inspection.

Complete facilities for pipe finishing are provided, including facing, threading, coupling, hydrostatic testing, galvanizing, coating, bundling and stenciling. The warehouse, 130 ft x 1404 ft, provides storage for 30,000 tons of pipe.

Two fuel oil systems are installed in the National Tube area, one at each end of the plant. A heavy oil system, consisting of a 300,000-gal storage tank, recirculating pumps, heaters and an unloading station, serves the skelp mill furnace and the boiler house. A non-recirculating system, containing a 1,000,000-gal storage tank, pumps and unloading station, serves the pipe mill furnaces. Both systems are protected by fire foam installations.



The hot strip substation shown here is typical of the stations in the plant. Power at 69,000 volts enters through four breakers, flows through the two transformers which are connected by segregated phase bus to indoor 13,800 volt switchgear inside of the building.

SERVICES AND MISCELLANEOUS

Fairless Works presents a total connected electrical load of 390,000 kva and sets up a demand of 86,000 kw. About one-third of the 40,000,000 kwhr used each month is purchased, the other two-thirds is generated in the plant. Purchased power comes from the utility company serving the area through the Biles Island substation, where two triple-rated 30,000/37,500/50,000-kva transformers reduce the voltage from 132,000 to 69,000 volts. A double circuit 69,000-volt overhead transmission line runs from this substation to the plant power house, feeding on the way three step-down substations:

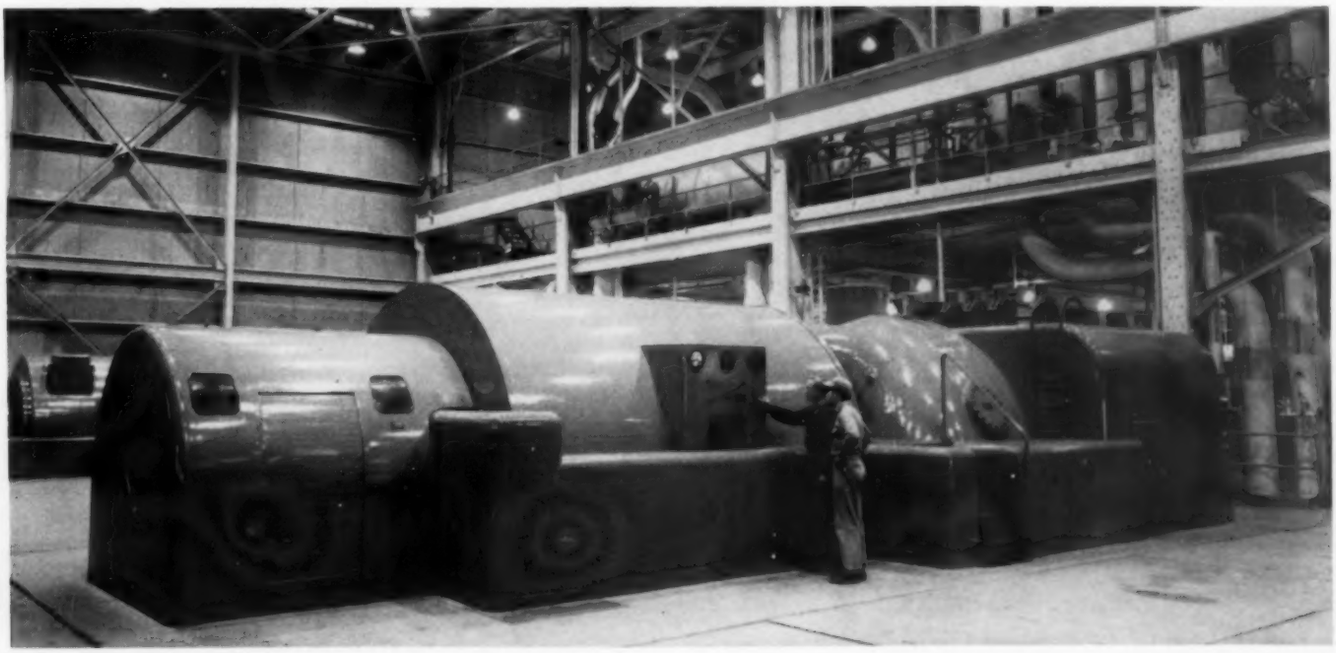
The main substation, with two 20,000/25,000/33,000-kva, 66,000/13,800-volt transformers, feeds three distribution centers in the sheet and tin area and one in the National Tube area.

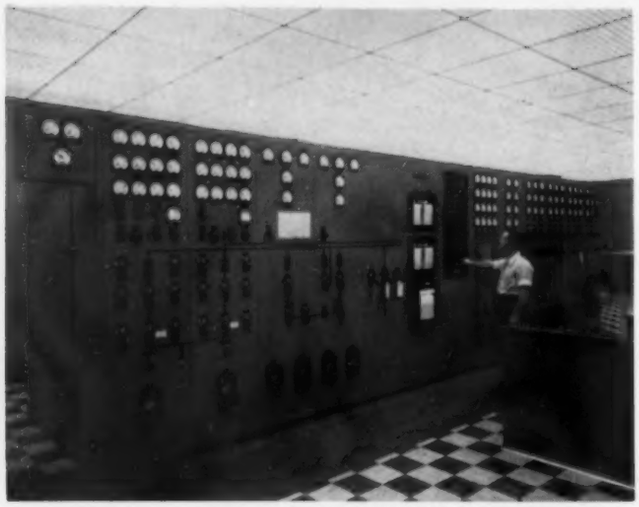
The hot strip substation, with two 20,000/25,000/33,000-kva, 69,000/13,800-volt transformers, feeds four distribution centers in the rolling mill area.

The pump house substation, with two 3750/4687-kva, 69,000/2400-volt transformers, feeds pump motors and waste treatment equipment in that area.

At the power house, there are two 20,000/25,000/33,000-kva, 69,000/13,800-volt transformers, as well as two 30,000-kw, 13,800-volt turbo-generators. Distribution from the power house to substations at the blast furnaces, open hearth, coke plant and maintenance shops is at 13,800 volts. All 13,800-volt distribution is through underground ducts.

Two 30,000-kw turbo-generators in the plant power house generate about two-thirds of power used in the plant.





These panels in the power dispatching room control the power house generation.

Control of the transmission and distribution system is centralized in a dispatching room at the power house.

Characteristics of the generating equipment are as follows:

	No. 1	No. 2
Generator		
Rating, kw	30,000	30,000
Rating, kva	35,294	37,500
Voltage	13,800	13,800
Frequency, cycles	60	60
Phase	3	3
Rpm	3,600	3,600
Cooling	Hydrogen	Hydrogen
Turbine		
Steam pressure, psi	850	850
Steam temperature, F	900	900
Condenser surface, sq ft	25,000	25,000
Circulating pumps, number	2	2
Circulating pumps, gpm	13,000	13,000
Circulating pumps, ft, H_2O	35	35
Condensate pumps, number	2	2
Condensate pumps, gpm	530	620
Condensate pumps, ft H_2O	160	160
Air ejectors	2-stage, 2-element steam jets	2-stage, 2-element steam jets

The No. 2 turbine is designed for automatic steam extraction at the 300-psi stage to the amount of 200,000-lb per hour. This steam is used for plant processes and for some steam driven auxiliaries in the power house.

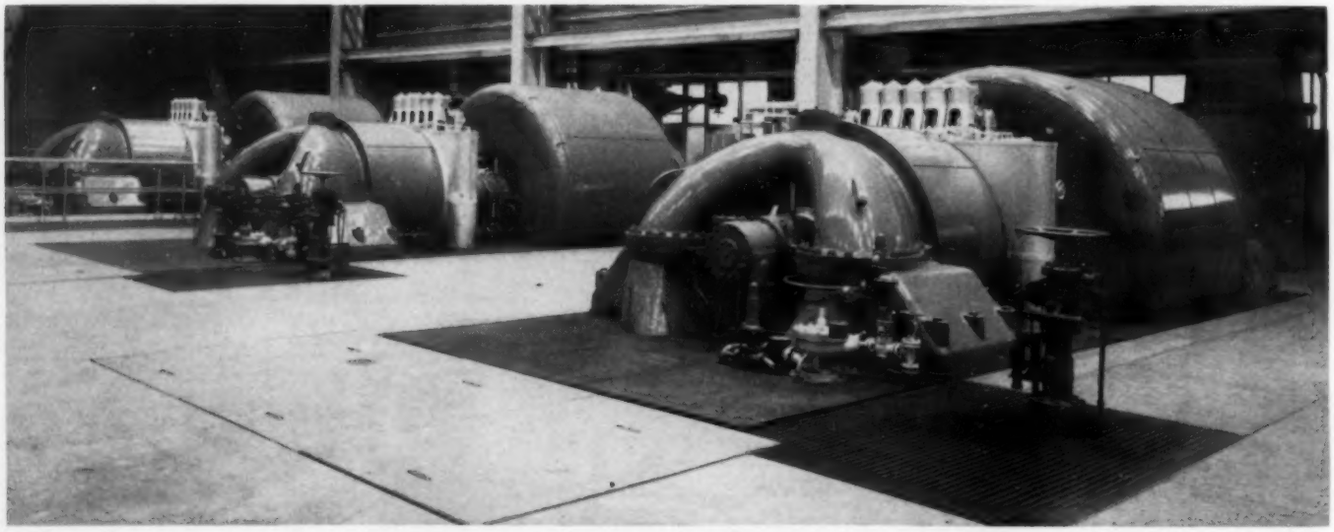
Constant potential 250-volt, d-c power is supplied by 19 rectifiers, located in the principal consuming areas. In the cold mill area are four 1500-kw units, serving respectively the substations for the four-stand co'd mill, the sheet temper mill, the five-stand cold mill and the electrolytic tin house. In the hot mill area, there are five substations serving the 45-in. slabbing mill, the 40-in. blooming mill, the 30-in. and 21-in. billet mills, the 10-in. bar mill and the hot strip mill. Each station houses a 1500-kw rectifier except those serving the billet mills and the strip mill, which have two each. Two 1500-kw rectifiers serve the open hearth area, and two 750-kw rectifiers serve the maintenance shops. The substation serving the blast furnaces contains two 1500-kw rectifiers, while the substation in the coke plant has two 500-kw units. The d-c system is not grounded, as it was deemed best to avoid ground currents which might damage underground metallic objects.

Steam is provided by three boilers each of 300,000 lb per hr capacity at 875 psi, 900 F. Each boiler is fired through six combination burners arranged in pairs at three different elevations on the front of the setting. The burners can handle blast furnace gas, coke oven gas and fuel oil in any combination. Blast furnace gas is the principal fuel.

Single pass, double section, tubular type air heaters preheat combustion air to temperatures as high as 800 F, depending on the fuel used. Superheaters are provided with automatic temperature control, whereby part of the superheated steam may be bypassed through a heat exchanger located in the mud drum of the boiler and then mixed with the steam leaving the superheater.

Induced draft fans on two of the boilers are turbine driven, with the turbines taking 850 psi steam and exhausting at 300 psi.

The three blast furnace blowers, located in the power house, are rated at 110,000 cfm, 35 psi.



Boiler feed water comes from five centrifugal pumps, each rated at 333,000 lb per hr at 1033 psi pressure. Feed water is heated in two 700,000 lb per hr spray-tray type deaerating heaters.

Make-up water, which amounts to about one-third of the total feed water comes from the plant service water system, and is pre-treated with lime and ferric sulphate, filtered through four gravity type filters and put through four zeolite softeners. The plant can treat 1200 gpm. An internal after-treatment of phosphate and sulphite is also used.

Power house auxiliaries are variously driven by electric motors and steam turbines. The latter exhaust at 15 psi back pressure, with the exhaust going to heat feed water. The use of motor and turbine drives provide flexibility to attain a proper thermal balance.

It will be noted that the plant is laid out with two individual steam systems, one of 850 psi pressure and one of 300 psi pressure. The 300-psi system is supplied by extraction from the No. 2 turbo-generator unit and the induced draft fan turbines, as mentioned above, by emergency service water pumps, by two pressure-reducing, desuperheating connections, and by the waste heat boilers previously described. Requirements of the systems amount to about 823,000 lb per hr high pressure and 463,000 lb per hr low pressure.

The power house also contains the three blast furnace turbo-blowers previously mentioned. These blowers have a normal rating of 110,000 cfm at 35 psi, and are equipped with constant volume control which automatically corrects for changes in atmospheric temperature and pressure. The turbines, rated at 15,700 hp, operate on 850 psi, 900 F steam, and are each equipped with a 10,400 sq ft surface condenser. Each condenser is provided with one 11,200-gpm, 30-ft head circulating water pump, two 230-gpm, 160-ft head condensate pumps and a two-stage steam jet air ejector.

Water requirements of Fairless Works are supplied by three separate distribution systems. Service water, at the rate of 230,000,000 gal per day, is drawn from the Delaware River through surface intakes or submerged offshore cribs, as dictated by river conditions. The water, after passing through bar racks and traveling screens, may go to wells from which four 46,000-gpm and two 16,000-gpm low lift vertical turbine type pumps move to a settling basin designed for 80 minutes retention.

About half of this water flows by gravity to the power house for cooling and condenser use, from where it is discharged back into the river. The other half of the water flows by gravity from the settling basin to the sumps of the service water pumps in the pump house. Four 20,000-gpm and two 6500-gpm vertical turbine type service water pumps maintain 60-psi pressure in the system supplying water to the various steel plant units.

If desired, the service water pumps may take water directly from the river, allowing a longer retention time in the settling basin for condenser water. Also, if necessary, the settling basin can be completely by-passed, with water going to the power house directly from the intake pumps. Intermittent chlorination is used to prevent slime accumulation in the system.

For special processes, water is provided from a separate system which draws water through caissons sunk into the ground with projecting radial pipes at the water strata level. Vertical turbine pumps maintain a pressure of 60 psi. The consumption of this system is approximately 15,000,000 gallons per day.

Water for drinking and sanitary purposes (4,000,000 to 5,000,000 gal per day) is supplied by a ground water well system completely independent of the other two systems.

All water and liquid waste from the various plant processes is treated and then reused in the plant or discharged into the river.

Chromic waste is treated with waste pickling solution and the resultant chromium sulphate is led to a clarifier where the addition of lime slurry precipitates the chromium as chromium hydroxide.

Waste pickling solution is gathered in two 200,000-gal storage tanks. Some is used in treating chromic waste, as previously mentioned, while the balance is normally sent to an outside manufacturer who uses it in his process. Facilities for neutralizing all waste pickling solution with lime slurry are available for emergency use.

View of one aisle in the central maintenance shop, showing battery of lathes.

Alkaline wastes, coming from tinning, continuous annealing and continuous cleaning lines, are used to increase the alkalinity of the acid and soluble oil wastes. Such wastes are accumulated in a 23,800-gal storage tank and fed into a clarifier, where lime slurry is added to give a pH value of about 9.0 and precipitate the metals from the solution. Floc formed here helps to clarify the effluent and remove some of the oils in the precipitated sludge.

The clarifier unit is 60 ft in diameter. Liquid enters a center compartment through an inverted siphon, receives mechanical flocculation and passes to an outer annular compartment for settling and scum flotation. Oil is skimmed from the surface by a rotating arm and pumped to a storage tank. Sludge is pumped to a lagoon. The overflow passes over a continuous circular weir at the tank periphery.

Soluble oil waste is directed to a 42,300-gal storage tank, then to a flash mixer where it is mixed with waste pickling solution or fresh acid. Effluent is taken to the clarifier.

Insoluble oil waste consists of palm oil in the effluent from skimmer tanks, plus some lubricating oils. This is decanted and put through a separator. Effluent goes to the terminal treating plant.

Water containing roll scale from the mills flows into pits where a detention time of 15 minutes permits settling. Two-thirds of this water is recirculated to the mills, while the remainder flows to the terminal treating plant.

Waste water from the water treatment plant, boiler houses, etc., flows to the terminal treating plant.

The entire flow of industrial waste waters, except that from the blast furnaces, passes through the terminal treatment plant. Here the water is aerated by compressed air, put through two stages of sedimentation and skimming. The clarified water may then be put into the river or back into the service water system of the plant.

Water overflowing from the thickener at the blast furnace goes to a separate clarification plant where it is mixed with lime slurry, put through a flocculator and clarifier. After a settling time of two hours, the water flows over a weir and is discharged into the river. Sludge is pumped to a storage lagoon.

Sanitary wastes are put through a conventional sewage plant consisting of a pumping station, comminutors, primary tank, enclosed trickling filters, secondary tank, chlorinating equipment, and sludge drying bed. Effluent flows into the river.

Fairless Works is served by two railroads through one plant entrance. A number of railroad yards are set up within the plant, including two (520 cars) for open hearth materials, maintenance material and miscellaneous freight, one (600 cars) for coal, ore and limestone, one (100 cars) for material for the rolling mills and as the pick-up point for outbound shipments, one serving the National Tube Division, and four (450 cars) for internal storage. Some 80 miles of standard gauge track is installed, all constructed of 115-lb rail and creosoted ties.

Internal switching is done by eighteen 120-ton, 1200-hp diesel engines and one 500-hp unit.

More than three miles of belt conveyors, 145 overhead cranes ranging to 450 tons in capacity, and a multitude of industrial trucks and special cars help to keep raw materials and products flowing through the plant.

Ventilation of the great concentrations of electrical equipment in the various motor rooms requires some 3,400,000 cfm of air, which is provided by 16 ventilating systems containing 146 fans and 26 electrostatic precipitators, and ranging in size from 32,000 cfm up to 570,000 cfm.

Throughout the plant, lubrication of major equipment is accomplished by recirculating oil systems or automatic grease systems, of the latest design, with less elaborate systems for the smaller units.

Chemical and metallurgical laboratories strategically located near the various producing centers provide facilities for the control and checking of materials and processes so as to meet customer requirements, as well as the checking of raw materials and experimental research on plant processes.

Complete maintenance services for the plant are provided in a group of buildings which includes central maintenance shops and storeroom. The shop building, 772 ft x 292 ft, houses the machine, forge, pipe, welding, rigger, boiler, carpenter, paint and electric shops, containing some 200 pieces of equipment such as machine tools, forges, furnaces, etc. The building is laid out in three bays, with a crane in each bay. Transfer cars are used for movements from one bay to another. Three railroad tracks enter directly into the building.

Another building, 483 x 196 ft, contains diesel and car repair shops, designed to service and maintain the locomotives, locomotive cranes, rolling stock and trucks used in the plant.

The central storeroom building is 600 x 122 ft, and is provided with a rail siding and loading docks. The truck docks have hydraulic platforms to facilitate the loading and unloading of trucks. The building is provided with storage bins and with monorails and conveyors for handling materials. Drum and tank storage for the various kinds of oil used in the plant is provided in a separate 200 x 122-ft fireproof building. In addition to a sprinkler system for fire control, a central ramp permits fire trucks to enter the building.

A 70 x 102-ft fire house located nearby contains a safety truck, two pumper trucks, two chemical trucks, two ambulances and miscellaneous vehicles.

The maintenance buildings are heated by floor-mounted space heaters, supplied with steam from the plant system. Power is supplied from a separate substation containing a 2500-kva transformer, two 1500-kva transformers and two 750-kw rectifiers for d-c.

The construction of Fairless Works set up housing problems which have been met by the building of two towns. Fairless Hills, with an ultimate capacity of 4200 homes, is a well planned community about five miles from the plant. Levittown, also convenient to the plant, can be expanded to 16,000 homes should it be necessary. Both settlements are planned with shopping centers, post-offices, churches, schools, parks, playgrounds and community centers—in short, everything essential to a complete community.

The design and construction of Fairless steel works was under the direct supervision of S. Landon, chief engineer (left), and S. P. Curtis, chief construction engineer (center), of the construction engineering bureau. C. C. Wales supervised the National Tube project.

Mesta 43" x 90" Universal Reversing Slabbing Mill

MESTA
SLABBING MILL

Designed and Built for...

FAIRLESS WORKS,
U. S. STEEL
CORPORATION

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

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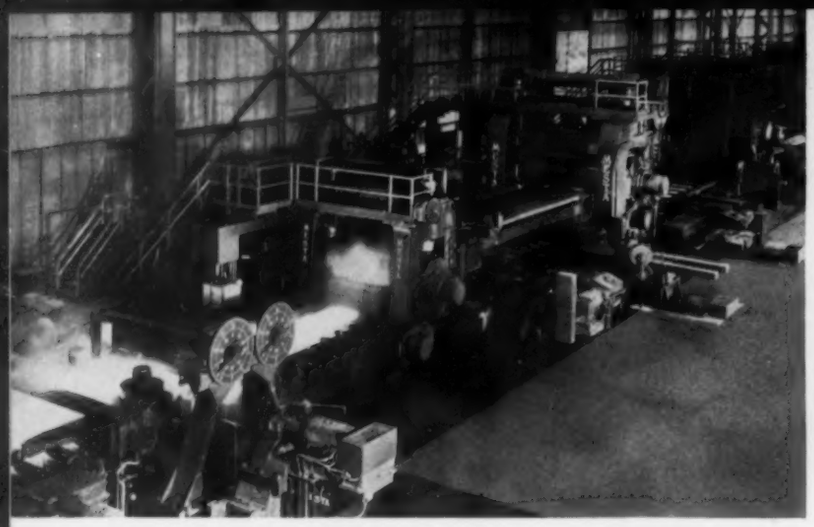
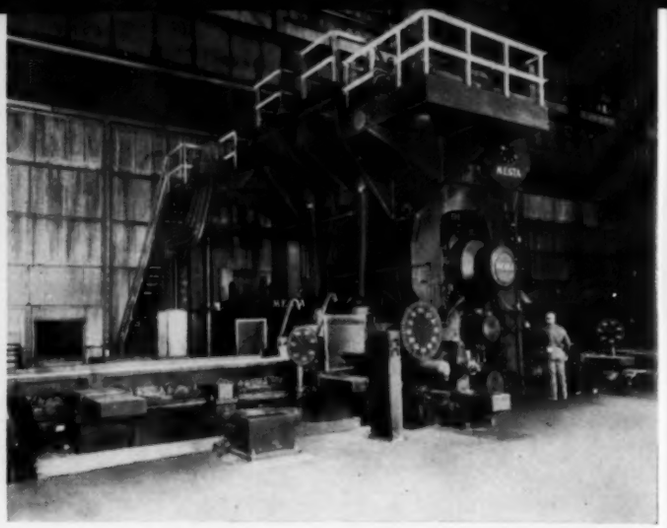


● Vertical Edging Mill, #1 Scale-Breaking Stand and 130" Spreading Stand on the Mesta 80" Continuous Hot Strip Mill

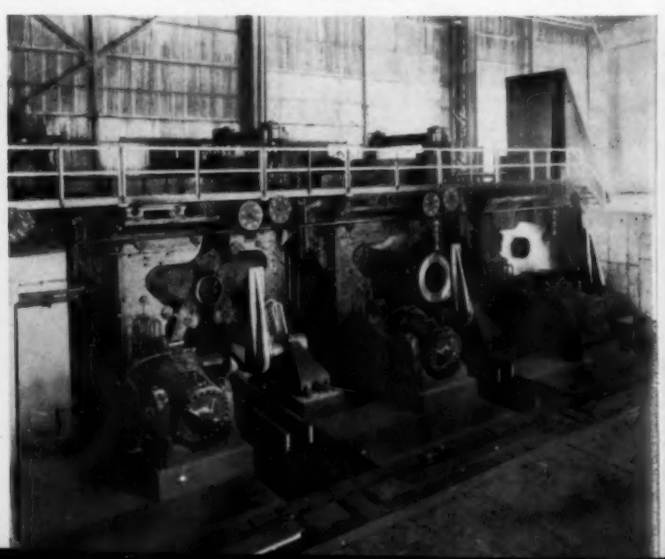


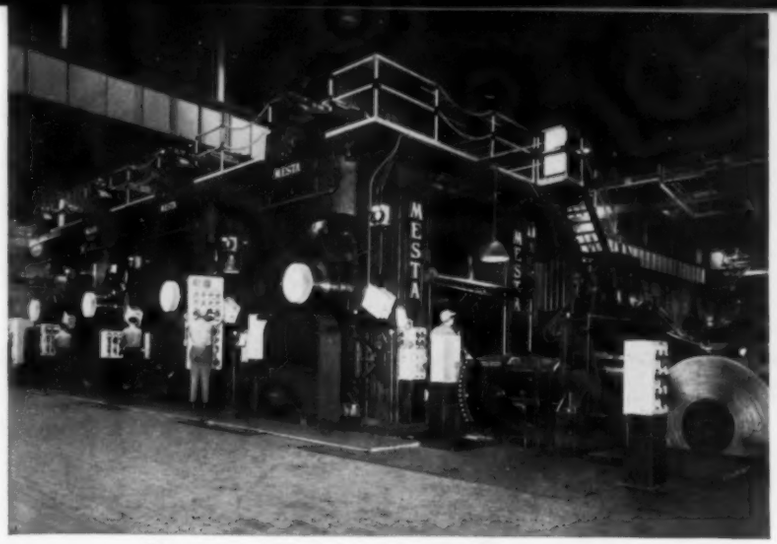
● Universal Roughing Mill Stand on the Mesta 80" Continuous Hot Strip Mill

Designed and Built by MESTA

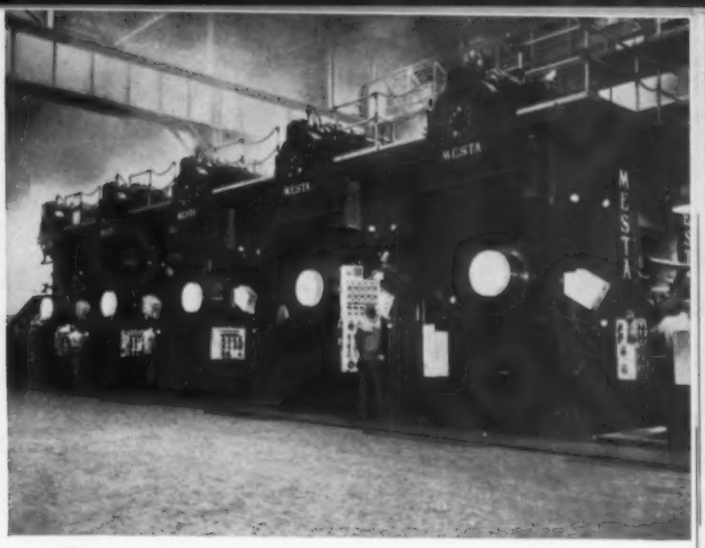
● Crop Shear, #2 Scale-Breaking Stand and Six Finishing Stands on the Mesta 80" Continuous Hot Strip Mill

● Three Down-Coilers on the Mesta 80" Continuous Hot Strip Mill



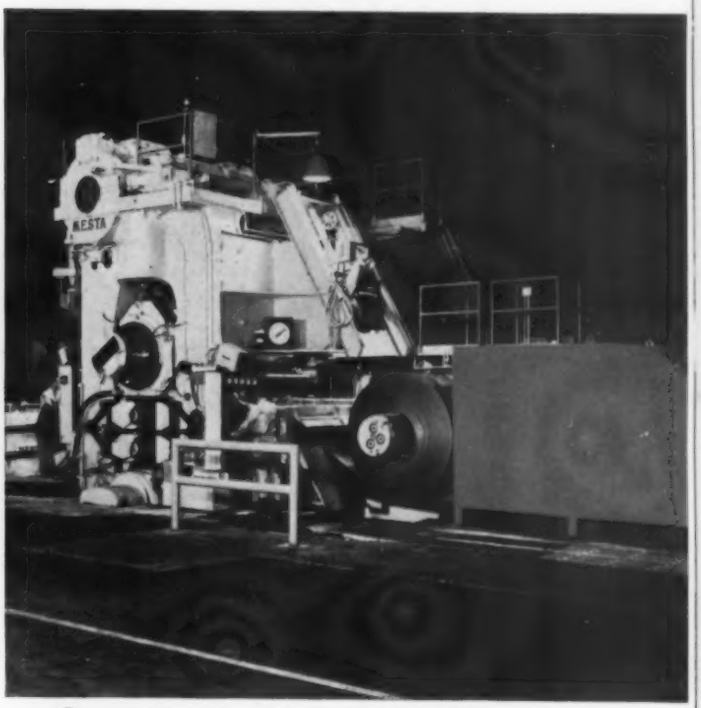


● Mesta 80" Four-High, Four-Stand Tandem Cold Mill



● Mesta 48" Four-High, Five-Stand, High-Speed Tandem Cold Mill

for FAIRLESS WORKS, U. S. STEEL CORPORATION



● Mesta 80" Four-High, Single-Stand Sheet Temper Mill for Coils

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PA. U.S.A.

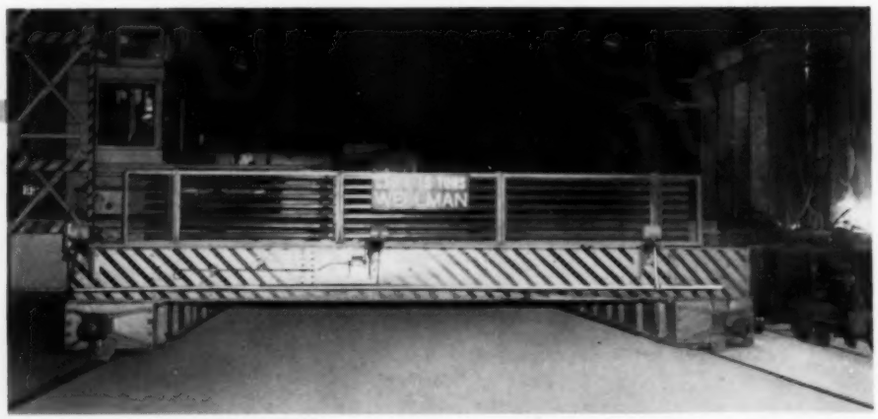
Wellman will build it

Special Cranes
Charging Machines
Ore Unloaders
Forging Manipulators
Car Dumpers
Gas Flue Systems
Gas Reversing Valves
Coke Pushers
Mine Hoists
Skip Hoists
Ore and Coal Bridges
Clamshell Buckets

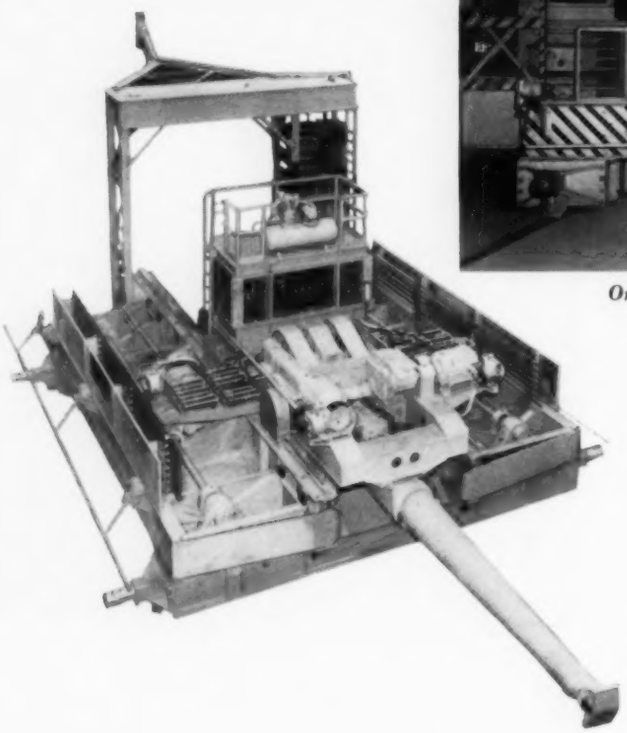
Wellman charging machines

efficiently serve open-hearth furnaces at

Fairless Works



One of four Wellman Charging Machines installed at the Fairless Works.

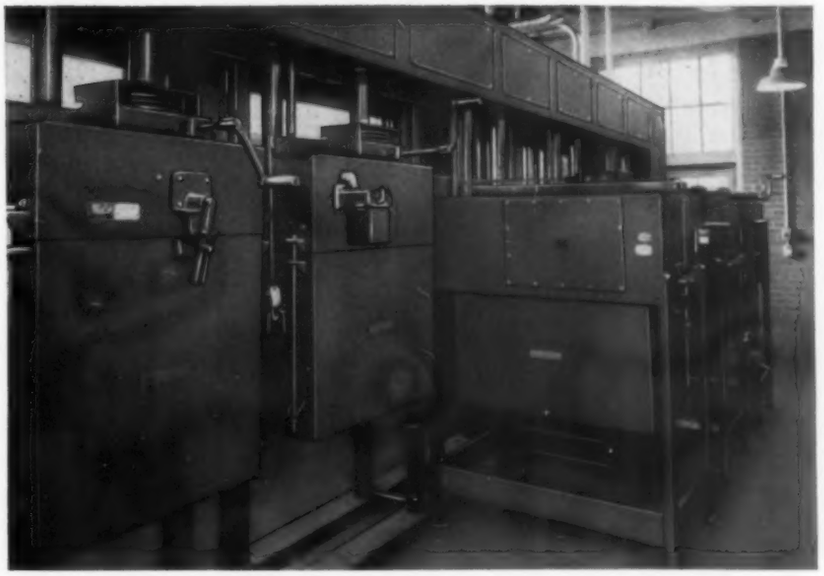


● This is one of four Wellman 15-ton Low-Type Open-Hearth Charging Machines serving the new Fairless Works of United States Steel Corporation. The efficient, dependable performance of these machines is typical of Wellman equipment throughout the steel industry. Take advantage of Wellman's half century of experience to help reduce *your* materials handling costs.

THE WELLMAN ENGINEERING COMPANY

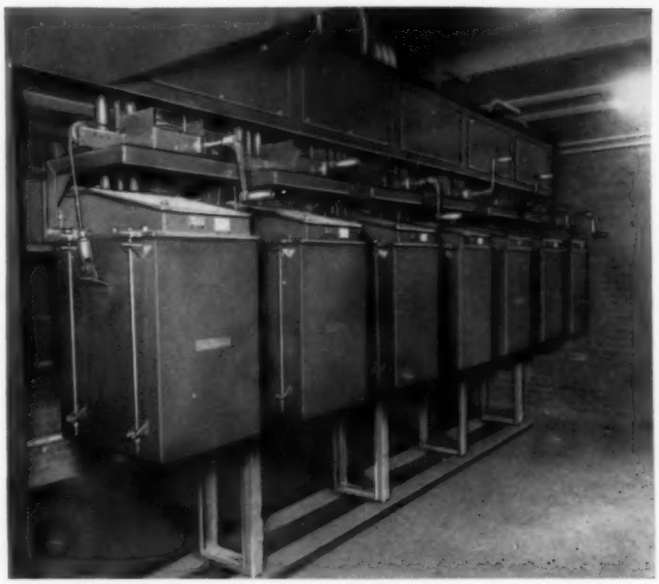
7010 CENTRAL AVENUE • CLEVELAND 4, OHIO

ROWAN *Oil Immersed* CONTROL



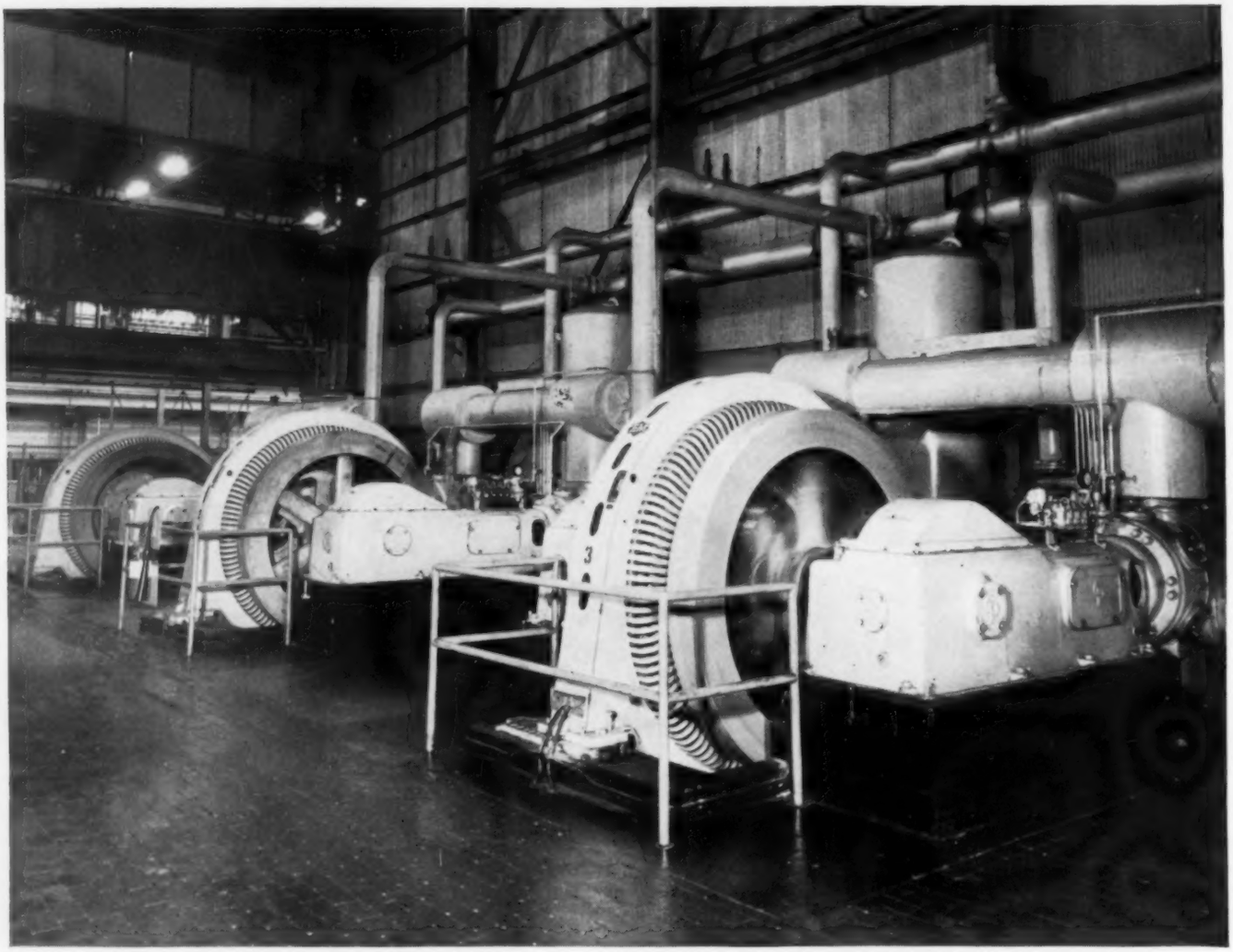
Actual installation photographs of Rowan Oil Immersed Centralized Control Units designed and fabricated to meet the requirements of U. S. Steel Corp. engineers and installed in the . . . .

FAIRLESS WORKS
UNITED STATES STEEL CORPORATION



ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.



Above are three 500 hp, 225 rpm, 2300 volt, 0.8 power factor E-M Synchronous Motors driving air compressors in the tin finishing department at the new Fairless Works of United States Steel Corporation. Three other 500 hp and five 300 hp E-M Motors also drive air compressors, in the hot strip and slab mill, central power station, open hearth pumphouse and sulfate building of the coke works.

Power costs held low on compressor drives at new Fairless Works

Supplying air for controls, tools, handling systems and maintenance equipment is vital business at Fairless Works. And cost of power for operation of the air compressors is an item to be watched in such a large mill.

That's exactly where the E-M Synchronous Motors fit in. They help contribute real economy and rugged reliability to compressor operation.

First of all, these 11 E-M Motors are capable of supplying approximately 2700 reactive kva to improve plant power factor, a significant element when you want to minimize power costs.

Secondly, the inherent high efficiency of E-M Synchronous Motors utilizes power most sparingly.

Other economies are accomplished by use of simple and low-cost full-voltage control for across-the-line starting. Maintenance economy is foretold by simplicity of E-M Synchronous Motor direct-connection . . . by extra strong lashing of E-M stator coils . . . by the high capacity of E-M cage windings to withstand repeated starting stresses.

To get top performance from your large compressor drives, discuss your needs with your nearest E-M sales engineer. And write factory for E-M Synchronizer No. 32, a special issue on air compressor drive applications.

ELECTRIC MACHINERY MFG. COMPANY
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EXACTLY WHAT YOU WANT THEM TO

take a GIANT step...

American Industry! Steel from the Fairless Works will put even more bone and muscle in your stride.

Walsh Construction Company* is proud to have been selected to take the lead in building the Fairless Works—the largest integrated steel plant in the world constructed at one time. On the truck farms of yesterday, a mighty industrial giant has risen overnight, and today its massive ore docks, blast furnaces, open hearths, coke ovens, and rolling mills, bear witness to the courage and ingenuity of its owners and the experience and versatility of its builders.

Expressed in terms of work units, the conversion by our forces of 15 square miles of farm land into a steel plant required:

800,000 cubic yards of concrete foundation involving over
10,000,000 square feet of concrete formwork.
1,000,000 feet of H-Pile driven.
100,000,000 pounds of reinforcing and miscellaneous steel.
1,500,000 cubic yards of foundation excavation.
11,500,000 cubic yards of general grading.
45 miles of piping, 80 miles of railroad,
. . . all in a period of two and one-half years.

**in a Joint Venture entitled the Walsh-Perini-Groves-Slattery Companies.*

Since 1899, in the days of "Mules and Men," Walsh has continually tackled tough construction jobs. Able men and good fortune combined to build the company on a solid foundation, and men of courage and vision have carried it on through the years. Today, as in the past, the Walsh Construction Company is ready with men and modern equipment to serve the construction needs of this fast-growing nation . . . anytime . . . anywhere!

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in free and compressed air

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RAILROADS
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WALSH CONSTRUCTION COMPANY

INCORPORATED 1899

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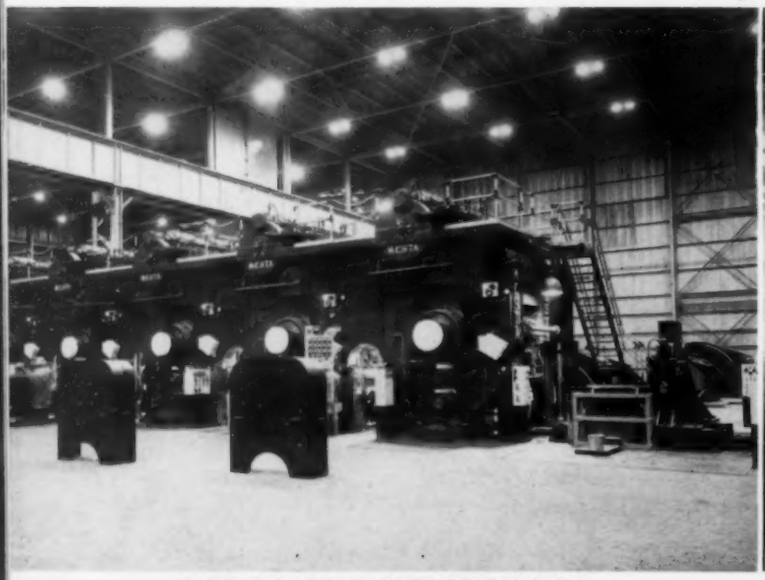
District Office: 785 Market Street, San Francisco 3, California
WALSH-CANADIAN CONSTRUCTION COMPANY, LTD., One Wellington West, Toronto, Ontario

Another STEEL MILL INSTALLATION By RIGGS DISTLER & CO., INC.

completed for

FAIRLESS WORKS, U. S. STEEL CORP.



5 STAND COLD REDUCTION MILL

40 IN. BLOOMING MILL

TYPICAL ELECTRICAL PANEL BOARD INSTALLATION

TYPICAL MOTOR ROOM INSTALLATION

THE COMPLETE SERVICES OF RIGGS DISTLER INCLUDE ENGINEERS, ESTIMATORS, AND SKILLED MECHANICS TO INSTALL:

- HEATING AND VENTILATING
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- POWER PLANTS
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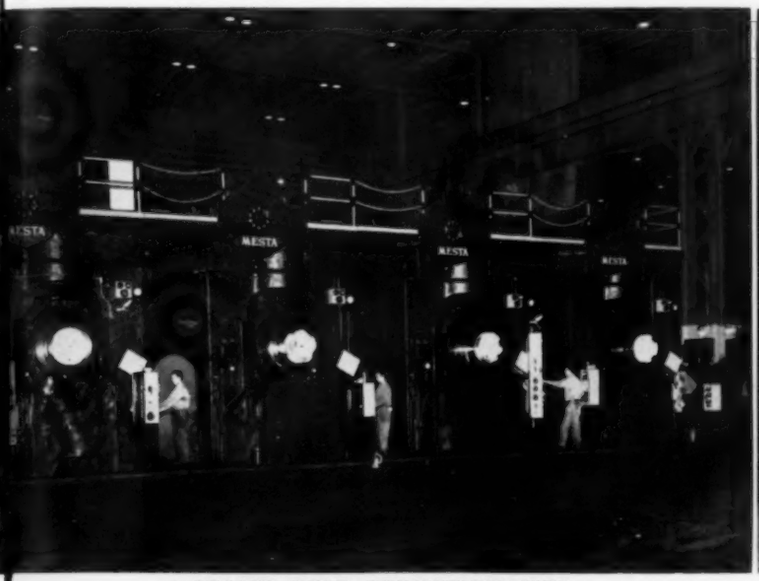
- OUTSIDE UTILITIES

FOR ALL TYPES OF STEEL MILL CONSTRUCTION

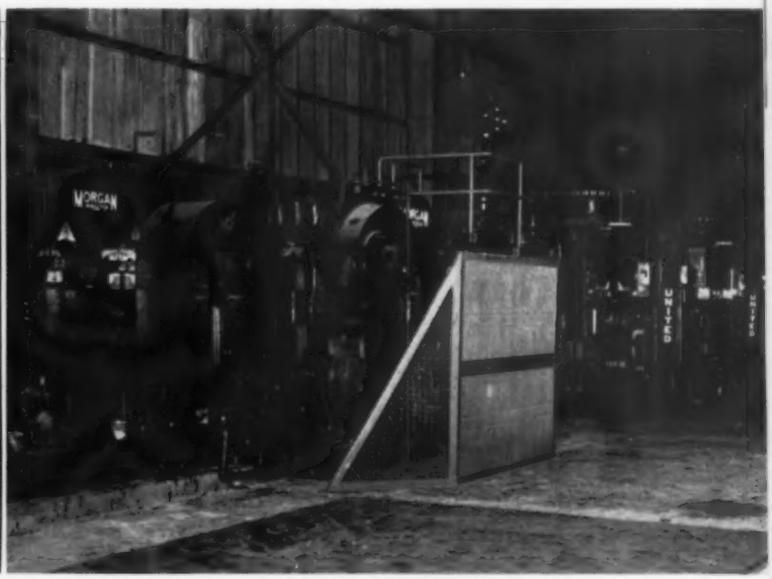
RIGGS DISTLER WAS PRIME CONTRACTOR FOR ERECTION OF EQUIPMENT AND ALL MECHANICAL AND ELECTRICAL INSTALLATIONS

in the

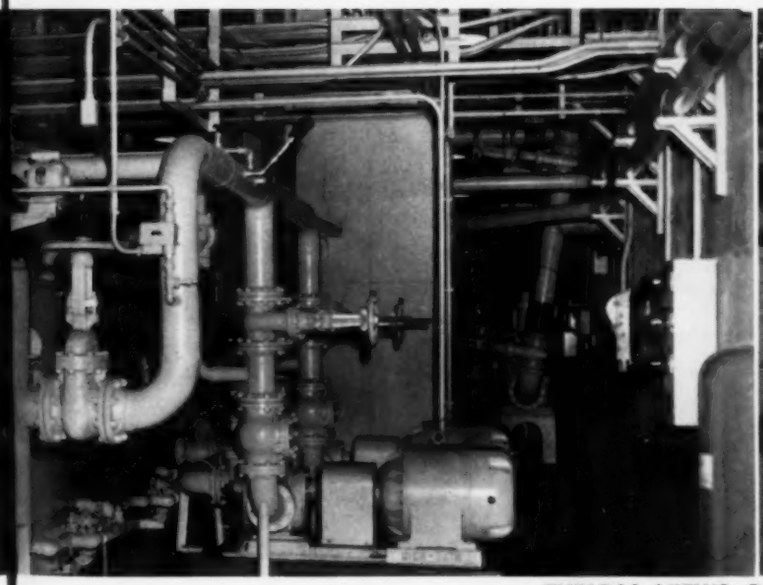
4 Stand Cold Mill • 40 In. Blooming Mill
5 Stand Cold Mill • Billet Mills
Central Maintenance Buildings

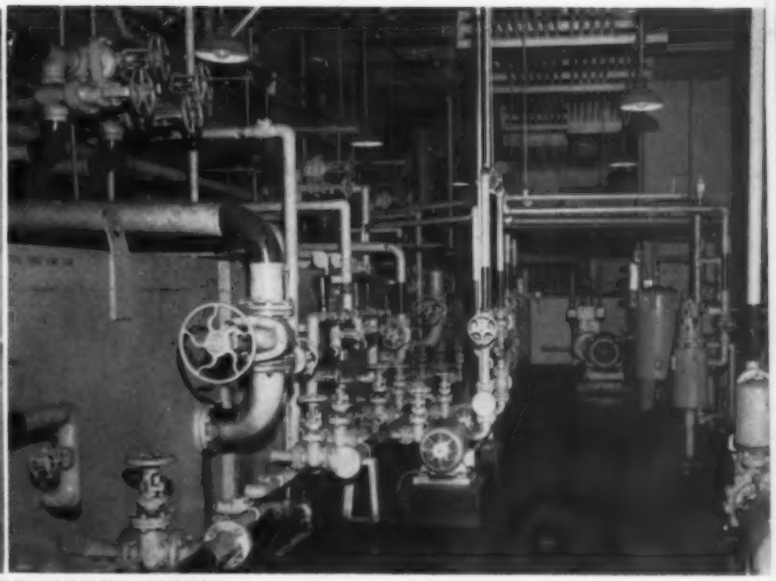


4 STAND COLD REDUCTION MILL



21 IN. BILLET MILL





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with principal offices and sheet metal and pipe fabricating shops located at

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Makes available to you all mechanical and electrical installations under ONE CONTRACT, ONE OVERHEAD AND ONE RESPONSIBILITY

80" Sheet Side Trimming and Shearing.

AETNA—STANDARD EQUIPMENT

FLAT-ROLLED EQUIPMENT

In flat-roll finishing equipment, Aetna-Standard engineered and built the following equipment:

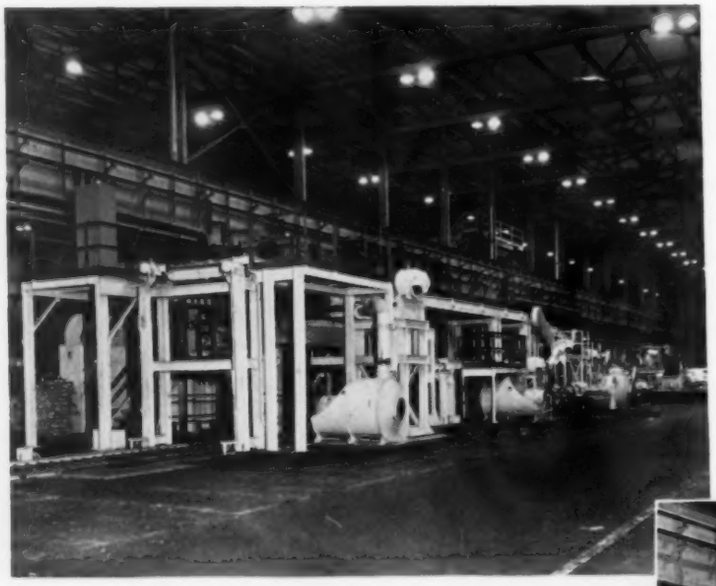
80" Sheet Side Trimming, Slitting and Recoiling.

80" Sheet Side Trimming and Shearing.

56" Wide Side Trimming and Shearing.

Sheet Stretcher Leveller.

For the Tin Mill Division, Aetna furnished a complete Hot Dip Tinning House with all auxiliaries; a side trimming and shearing line; a side trimming and recoiling line; and the classifying equipment for the electrolytic tinning line.



56" Side Trimming and Shearing.

80" Side Trimming, Slitting and Recoiling.

Stretch Reducing Mill of the 1½" to 4" Continuous Butt Weld Pipe Mill.

IN FAIRLESS WORKS

PIPE MILLS

Aetna-Standard designed and built two continuous butt weld pipe mills for the Fairless Works.

The No. 1 Mill produces pipe in size range ½" to 1½" at speeds up to 1250 feet per minute. The No. 2 Mill size range is 1½" to 4" at speeds up to 650 feet per minute.

Both mills incorporate a Rotary Flying Hot Saw which makes possible the higher running speeds. Both mills are equipped with a screw type kickout, providing a foolproof method of changing direction of pipe travel.

Two screw-type cooling beds were incorporated in each mill for cooling and straightening pipe.

aetna's major product lines

- √ Continuous Coating Lines
- √ Flat-Rolled Finishing Equipment
- √ Drawbenches
- √ Rolls
- √ Continuous Butt Weld Pipe Mills
- √ Seamless Tube Mills
- √ Machinery for Rubber and Plastics

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
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Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

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Electrical Contractors

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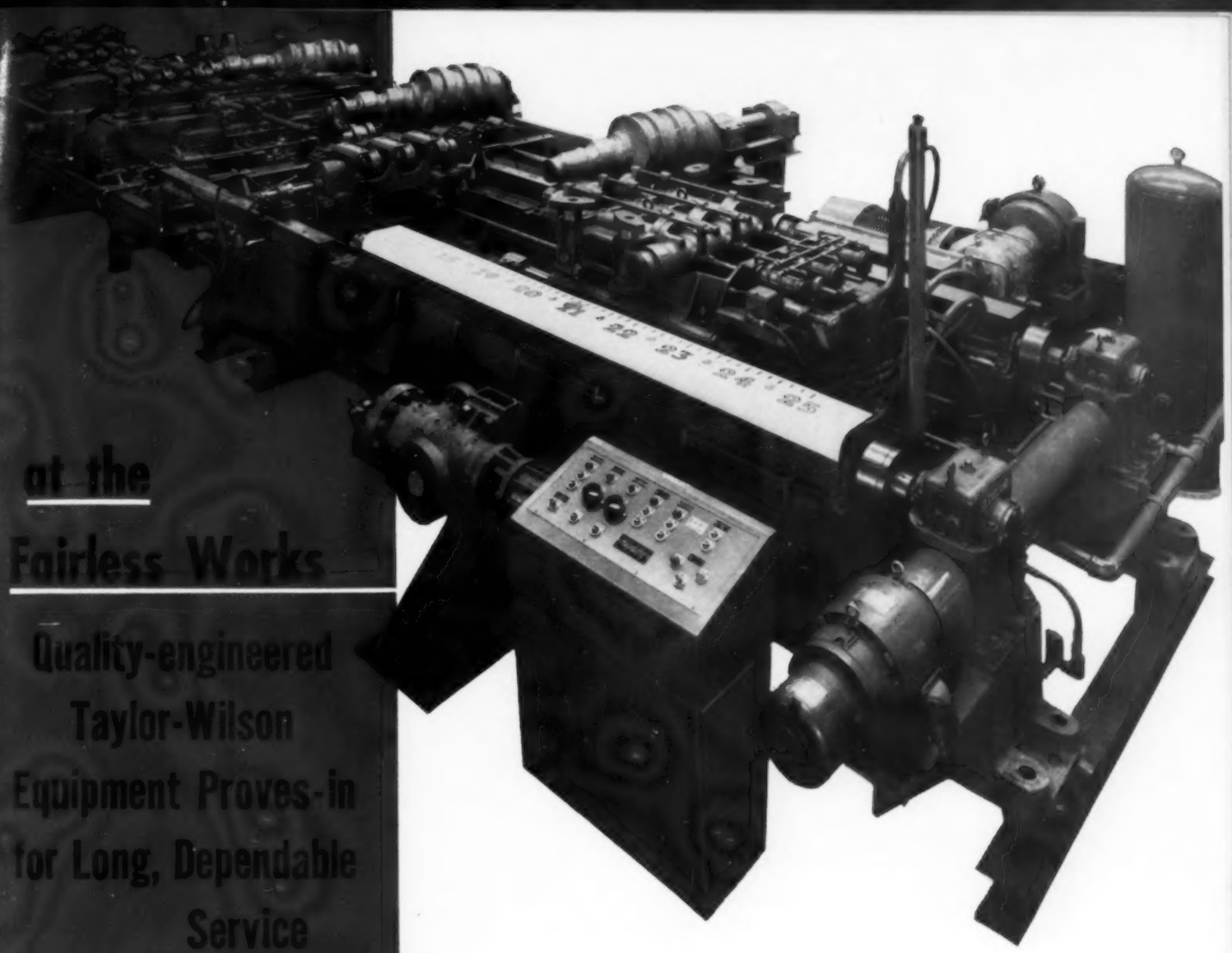


at the Fairless Works

Quality-engineered Taylor-Wilson Equipment Proves-in for Long, Dependable Service

Pipe Mill Finishing Equipment installed by Taylor-Wilson at the Fairless Works:

5 Hydrostatic Testers
Pneumatic Tester
Water Filtration System
Mechanical Press Straightener
Mechanical Crushing Shear
High Speed Straightener
Galvanizing Plant
Automatic Handling Equipment

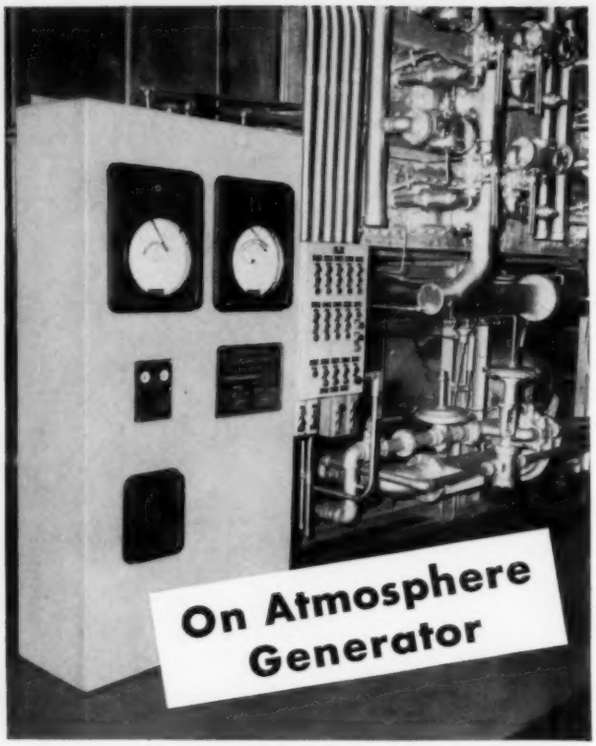
The sound engineering practices of Taylor-Wilson are evident in another dependable installation of pipe mill finishing equipment at the Fairless Works of the National Tube Division, United States Steel Corporation. Dependable installations like this are the product of more than 70 years of quality engineering and building. As the nation's oldest producer of pipe finishing equipment, Taylor-Wilson is proud to have engineered and built this pipe finishing equipment for the nation's largest steel producer.

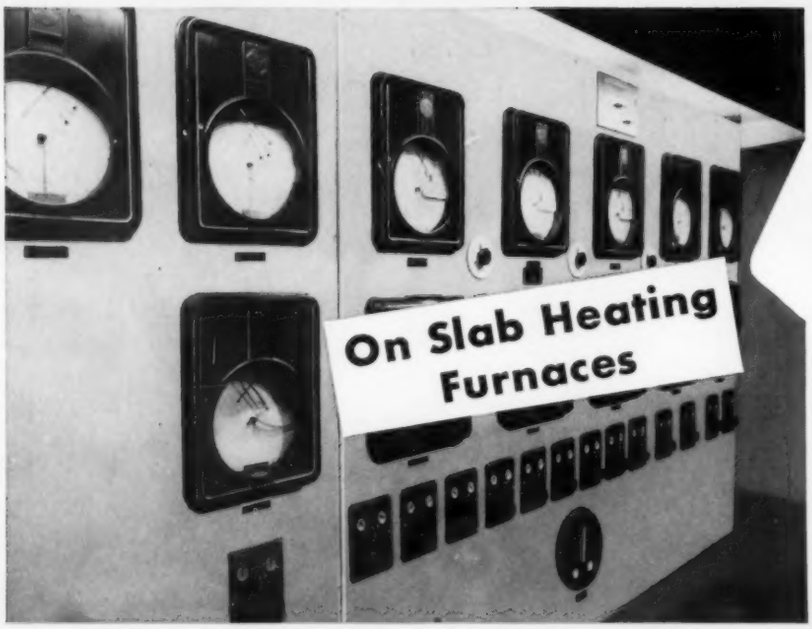
Taylor-Wilson

Manufacturing Company

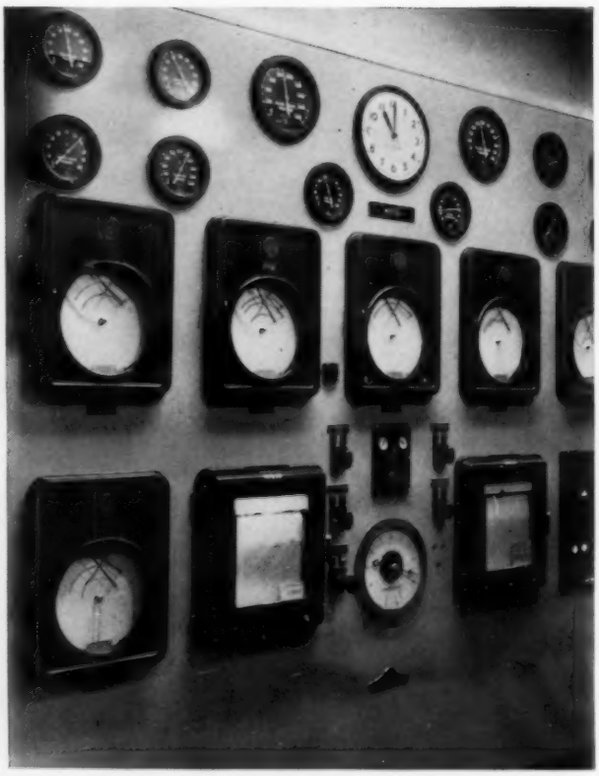
Pittsburgh 22, Pa. • McKees Rocks, Pa.

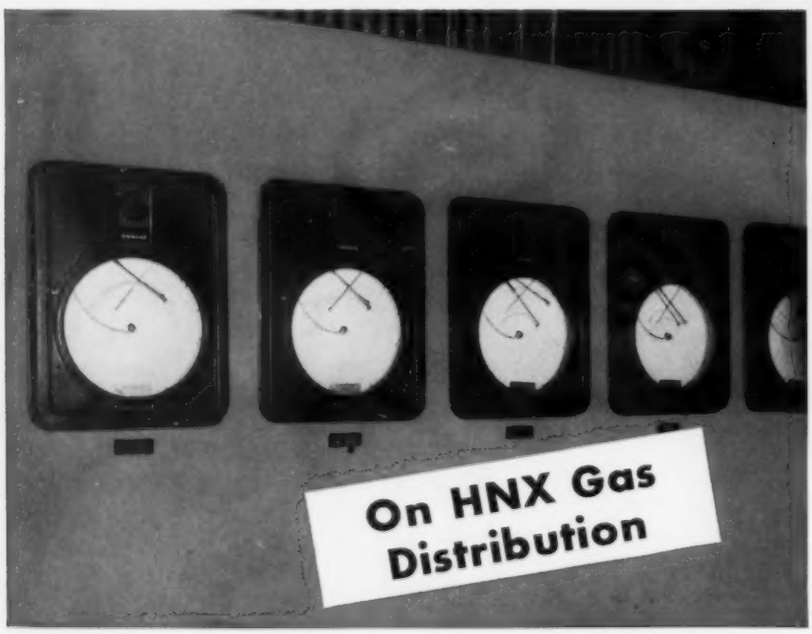
Engineers–Builders of Rolling Mill Machinery and Auxiliary Equipment; and Complete Pipe Mill Finishing Equipment — Hydrostatic Testers, Hydraulic Expanders, Cut-off Machines, Cut-off Feed Tables, Coupling Screw-ons, Scrap Shears, Crushing Presses, Handling Equipment, End Facers, Rotary Straighteners, Drifters, Gag Straighteners, Galvanizers.





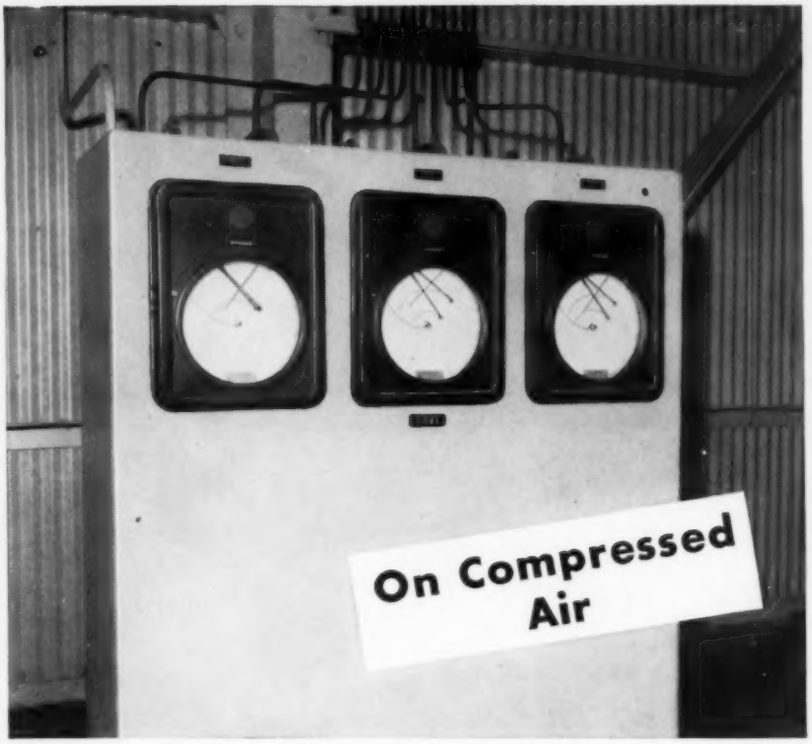
BAILEY

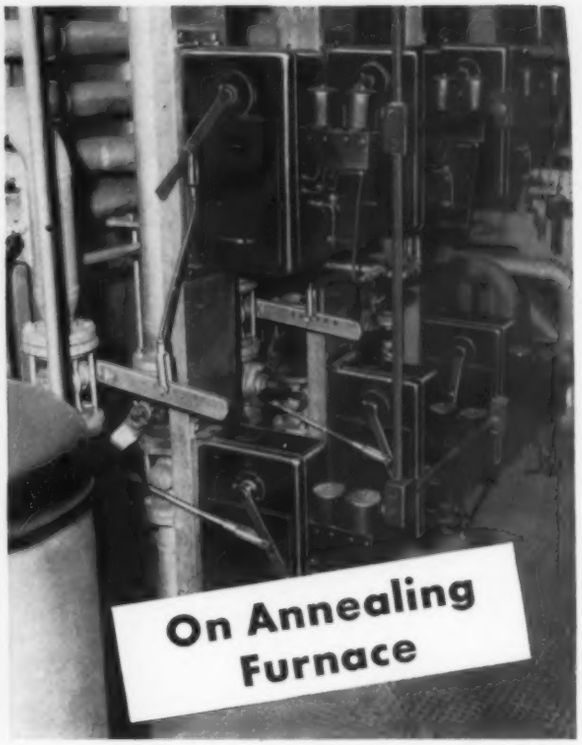




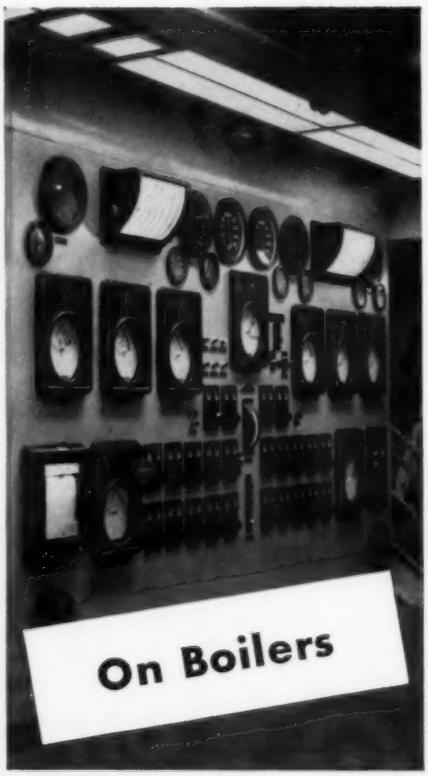
Formula for Cutting

[Bailey Design + Bailey Engineering + Bailey Service]





at FAIRLESS WORKS



Bailey Meters and Controls help U. S. Steel Corporation to secure optimum performance from this new Mill . . .

At Fairless Works you will find Bailey Meters and Controls helping to simplify and improve the operation of slab and billet heating furnaces, atmosphere generators, annealing furnaces, multi-fuel-fired boilers, waste heat boilers, utility distribution and plant water supply facilities.

Automation and Instrumentation by Bailey stands ready to help you improve the operation of steel mill equipment. It maintains product quality, saves fuel, upgrades operators, reduces "down time" and cuts cost per unit of production.

Call your local Bailey district office for recommendations on how Automation and Instrumentation may be applied to modernize your mill. P-29-2

Production Costs

= [Greater Savings per Fuel Dollar]

BAILEY
METER COMPANY
1047 IVANHOE ROAD
CLEVELAND 10, OHIO
Complete Controls for Process Plants

BAILEY METERS
Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW LEVEL
RATIO

TORRINGTON BEARINGS Carry The Load

Also Used For Many Auxiliary Units

Illustrated here are eight units at the mighty Fairless Works of United States Steel Corporation in which there are applications of Torrington Bearings. Other bearings were supplied for many auxiliary applications such as drives, pinion stands, coilers, etc.

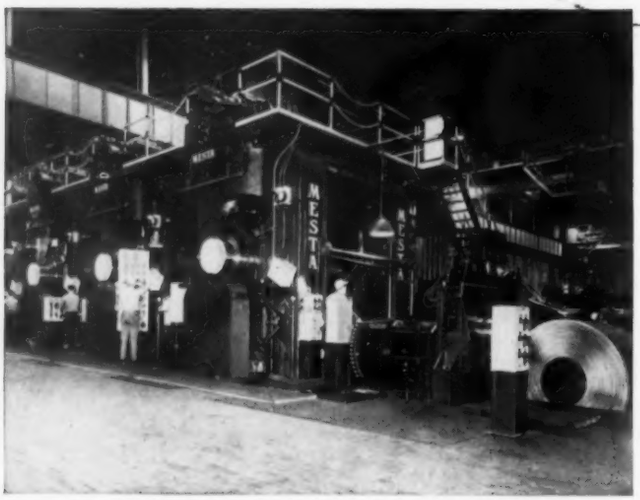
These rugged bearings are designed and manufactured for today's toughest steel mill applications. They are built from the highest quality electric furnace alloy steels and heat treated according to the most advanced metallurgical procedures. Their precision tolerances and finishes cut friction to a minimum.

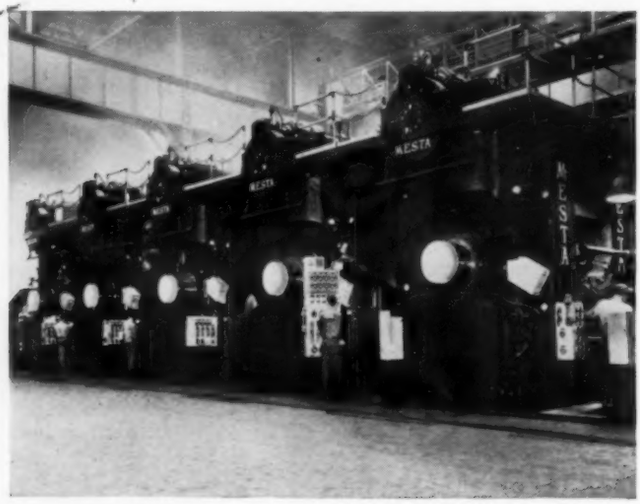
Torrington Bearings give long, efficient, low-maintenance service.

THE TORRINGTON COMPANY

South Bend 21, Ind. **Torrington, Conn.**

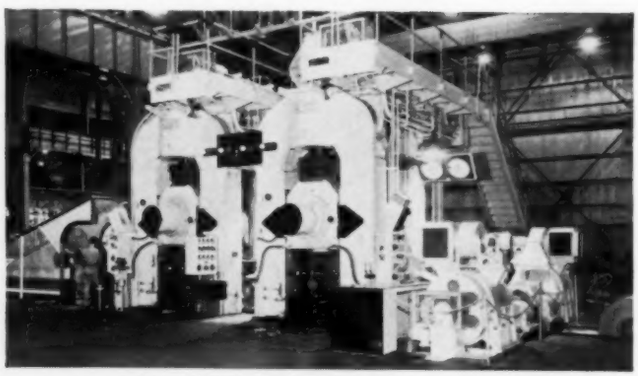
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers





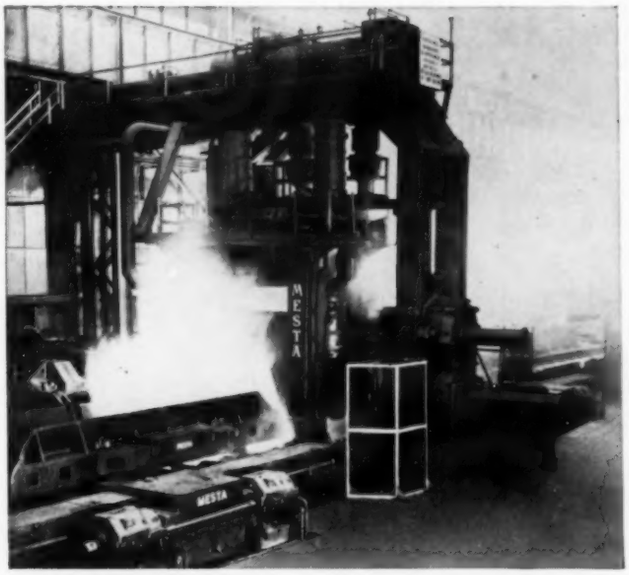
Torrington Work Roll Bearings are used in both the four and five stand Mesta Cold Mills. Back-up roll thrust is carried on *Torrington 2-Row Tapered Roller Bearings.*

24 Torrington Work Roll Bearings are used on work rolls of 6 finishing stands of Mesta's modern 80" Continuous Hot Strip Mill. *2-Row Tapered Roller Bearings* are used in back-up roll thrust positions.

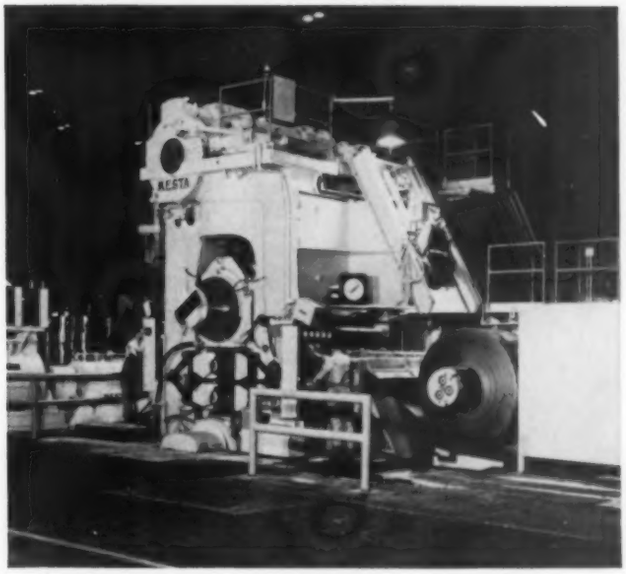


The Bliss Tin Temper Mill uses *Torrington Work Roll Bearings* and *2-Row Tapered Roller Bearings* for thrust, mounted with oil film bearings on back-up rolls. A 2-High Sheet Temper Mill is also equipped with *Torrington Roll Neck Bearings.*

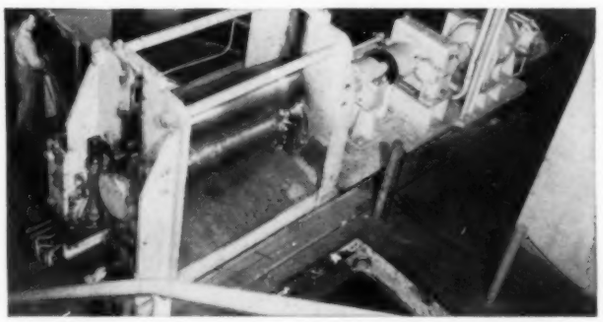
For These Major Units At Fairless Works



This Universal Reversing Slabbing Mill, one of the largest and fastest built by Mesta, is equipped with *Torrington Roll Neck Bearings* on the vertical rolls.



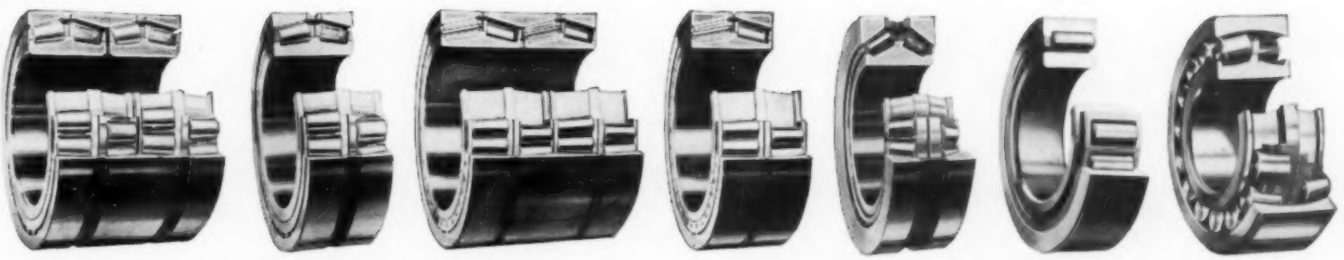
Torrington Work Roll Bearings and *2-Row Tapered Roller Bearings* for back-up roll thrust help keep this Mesta Sheet Temper Mill rolling efficiently and with minimum maintenance.



This scrap baller uses *Torrington Spherical Roller Bearings* and *2-Row Tapered Roller Bearings.*

Torrington Spherical Roller Bearings and *Radial Roller Bearings* keep Ingot Cars rolling smoothly.

TORRINGTON BEARINGS USED IN FAIRLESS WORKS' UNITS ILLUSTRATED



4-Row Tapered Roller Bearing —Bronze Cage

2-Row Tapered Roller Bearing— Bronze Cage

4-Row Tapered Roller Bearing —Pin Type

2-Row Tapered Roller Bearing —Pin Type

Steep Angle 2-Row Tapered Roller Bearing

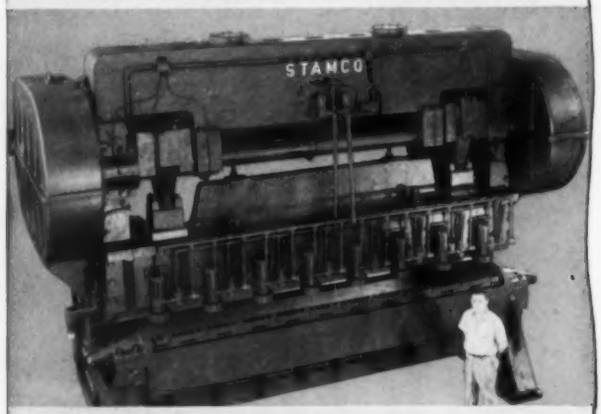
Radial Roller Bearing

Spherical Roller Bearing

For Special Operations in Steel Mills...

STAMCO 80" Side Trimming Unit

STAMCO Coil Box, coil opener and feeding unit



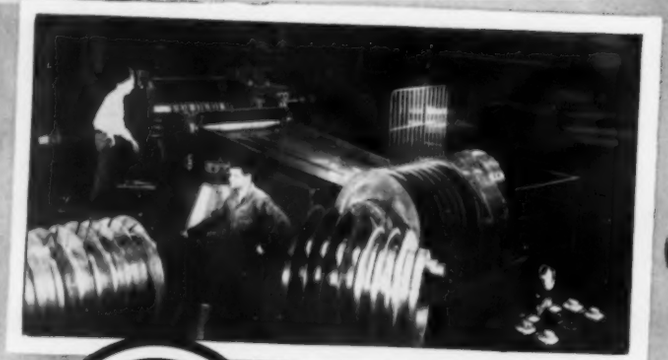
STAMCO 1¼" x 180" plate shear

Call or write

Stamco

for the equipment you need

For mill or warehouse use on ferrous or non-ferrous material, STAMCO has a model or size to fit your needs—or can make it for you. If you use trimming units, plate shears, slitting units, coil openers or any other special steel mill equipment, it will pay you to write us. No obligation.



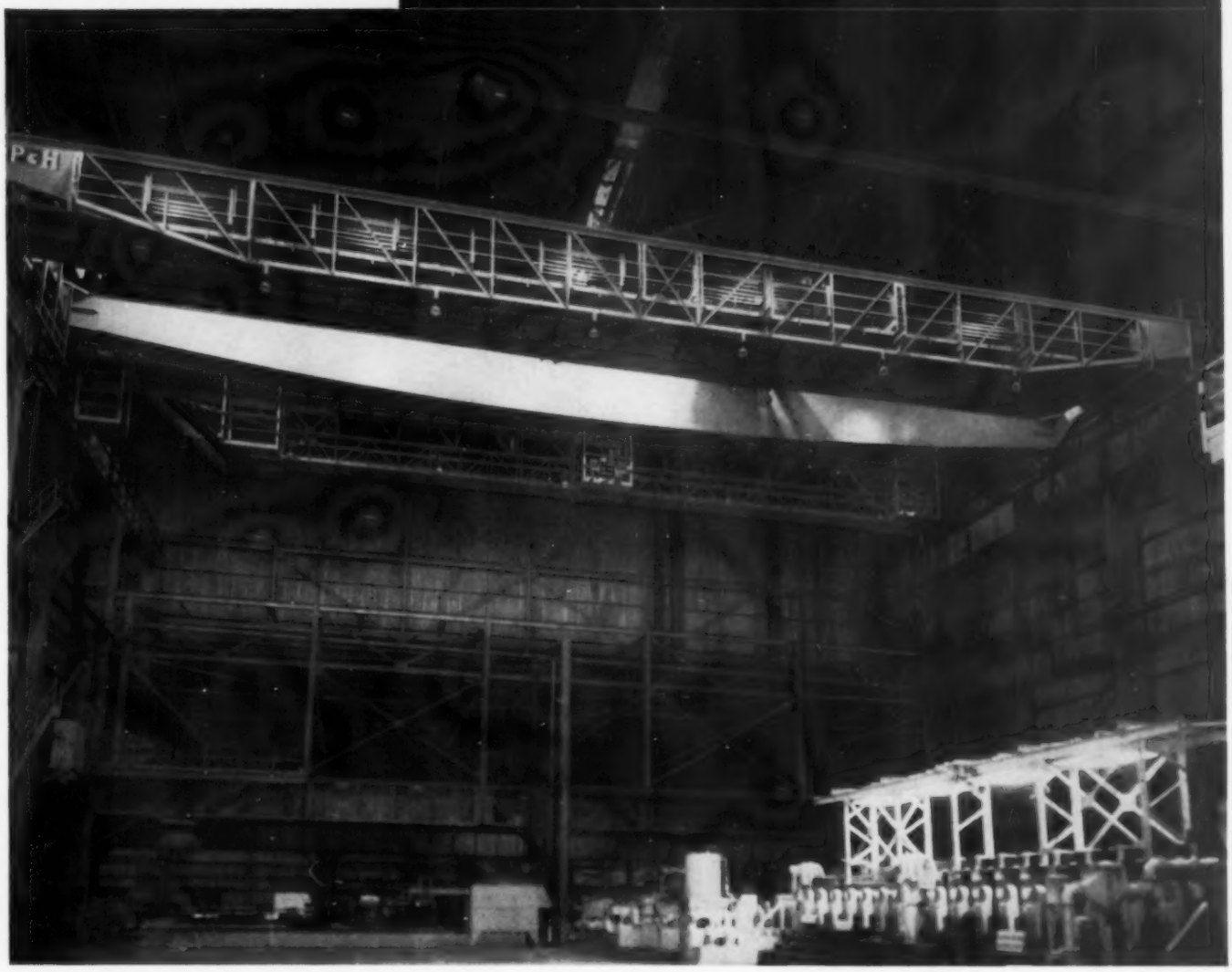
STAMCO 48" Slitting & Coiling Line 15000# coil capacity

STAMCO 72" Heavy Gauge Side Trimming and Slitting Unit equipped with a double set of feed and delivery pinch rolls.

• LAY YOUR SHEARING PROBLEMS AT STAMCO'S DOOR •

STAMCO, Inc., New Bremen, Ohio

AGAIN FOR UNITED STATES STEEL...



P&H mill-type cranes

In the magnificent new Fairless Works . . . as in other plants of U. S. Steel Corporation . . . P&H Mill-type Cranes are serving in number.

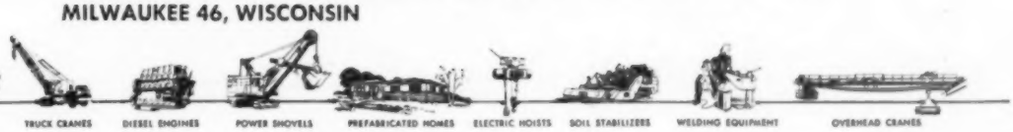
Built in excess of the minimum requirements of the A.I.S.E. specification, P&H Mill-type Cranes combine important features in design and construction that insure long, dependable service . . . with lowest maintenance time and costs.

P&H OVERHEAD CRANE DIVISION

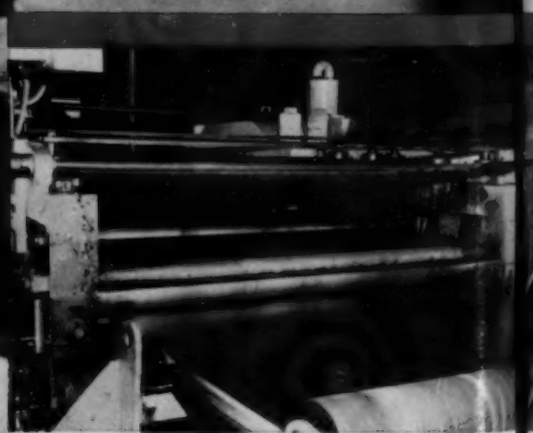
HARNISCHFEGER CORPORATION

MILWAUKEE 46, WISCONSIN

the P&H *Line*



TSP carries

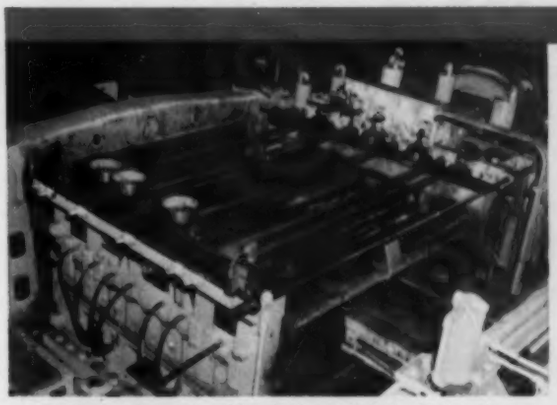


TSP Leveller Rolls on all Levellers

TSP Wheels on
200 ton Hot Metal Crane

plenty of weight at FAIRLESS

As U. S. Steel's Fairless Works turns out millions of tons of steel, "Tool Steel Process" hardened products will carry an important share of this enormous production job. TSP products were among those selected by the Fairless Works because of their satisfactory performance in other U.S.S. mills. Our long experience in the Steel Industry, our special production facilities, metallurgy and engineering . . . all combine to make TSP products the standard of quality — your best investment.

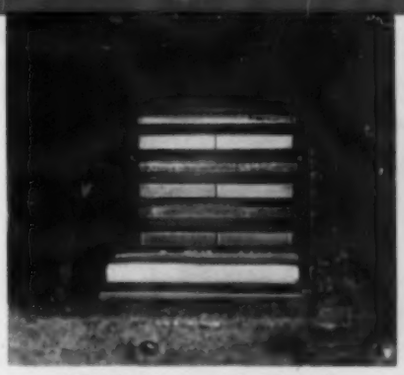


TSP Racks, Gears, Levelling Rolls on Hallden Flying Shear

TSP Wheels on Wellman Charging Machine

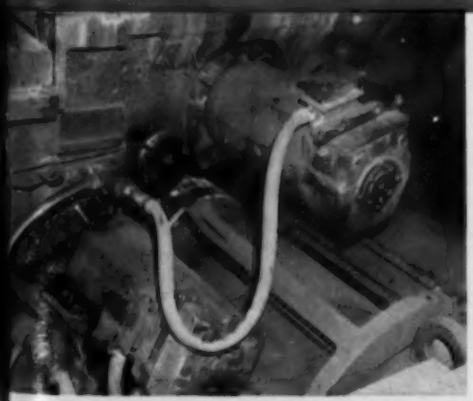
HERE'S WHY

TSP products are hardened by our special process. The file hard surface to full depth of permissible wear gives maximum life. The core, refined for toughness and ductility, gives maximum strength. You receive an absolutely positive written guarantee that TSP products will give a longer life in the same service than any other product.



TSP Drive Gears on Ore Unloader

"Tool Steel" Cold Rolling Rolls on Tin Temper Mil



TSP Drive Gears on Hot Strip Down Coiler

TSP products including Gears, Pinions, Track Wheels, Shafting, Leveller Rolls, Backup Rolls and Cold Rolling Rolls are included on equipment in every department of the Fairless Works.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U. S. A.

AD NO. 1006

THE WORLD STANDARD OF QUALITY SINCE 1909
FOR GEARS • PINIONS • ROLLS • WHEELS AND OTHER HARDENED PRODUCTS

in 'n out

Water lines are life lines at the new Fairless Works. Universal Concrete Pipe Company, the world's largest manufacturer of concrete culvert and sewer pipe, is proud of its Philadelphia plant and the part it played in the Fairless story.

Universal produced two miles of 48-inch concrete pressure pipe, in 16-foot lengths, for U. S. Steel Corporation's newest operation. All this is to bring water in.

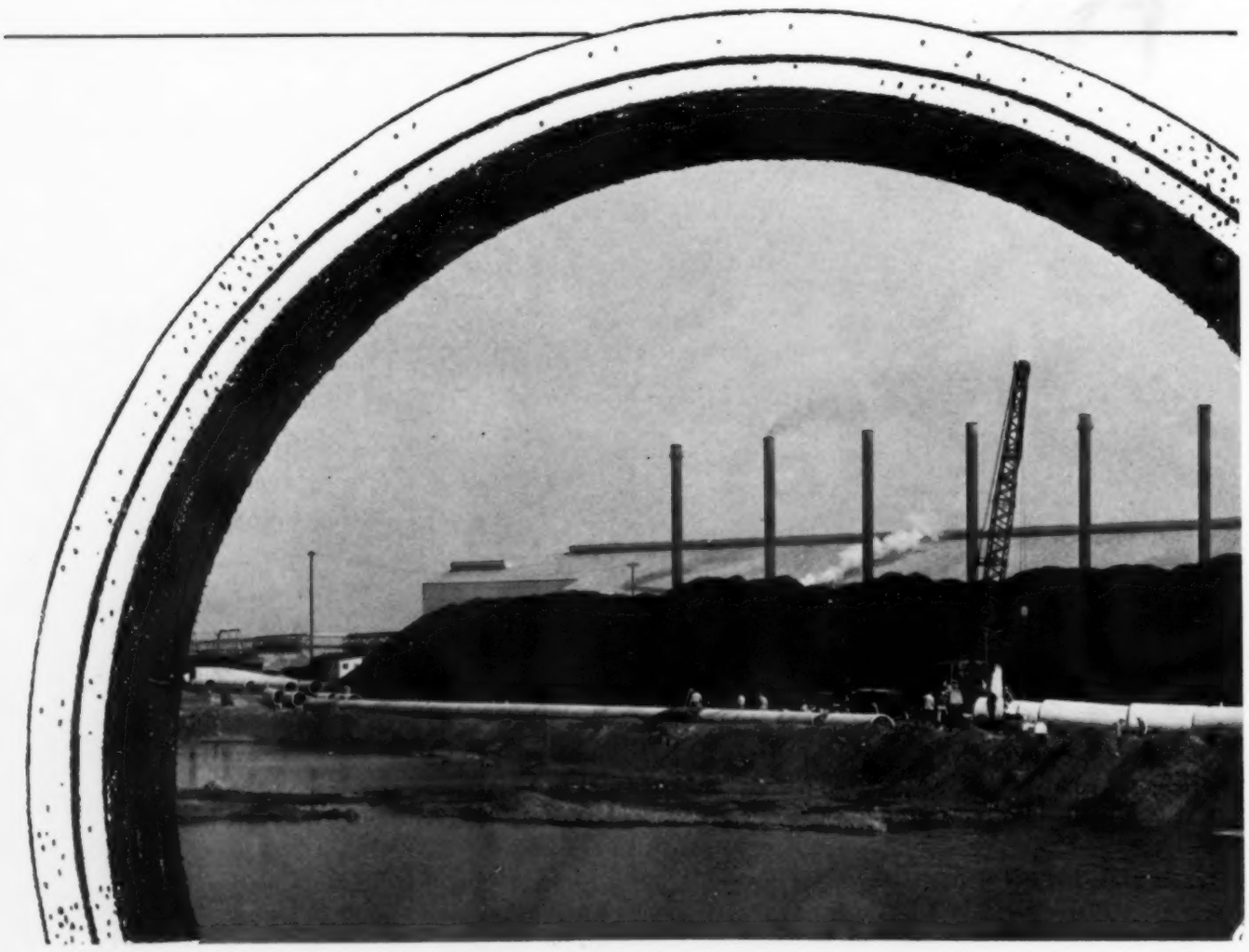
Universal also provided the reinforced concrete sewer pipe to carry out the water wastes and sewage at Fairless

In 'n Out goes the water at Fairless through the best concrete pipe that can be made — a Universal certainty at any of its 25 plants throughout the country.

Universal Concrete Pipe Co.

297 S. High St., Columbus 15, Ohio

A Subsidiary of American-Marietta Co.



a few of the many types of
SPRAYING SYSTEMS CO.

spray nozzles

installed at the
Fairless Works

. . . for such operations as roll cooling on hot and cold mills • descaling • runout table cooling • pickling line • cooling slabs on transfer table • cooling ingot molds • cooling open hearth tunnels or checkers • cooling pigs • coke chemical processing • spraying lubricants • and air and gas washing

For every spraying operation, you will find Spraying Systems spray nozzles offer impressive, measurable advantages. That is why they have been so widely selected for application in the Fairless Works. Spraying Systems spray nozzles are made in a very wide range of types and sizes for exact performance to meet your specifications . . . products of America's leading designer and manufacturer of spray nozzles for industry. Your inquiry is cordially invited.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

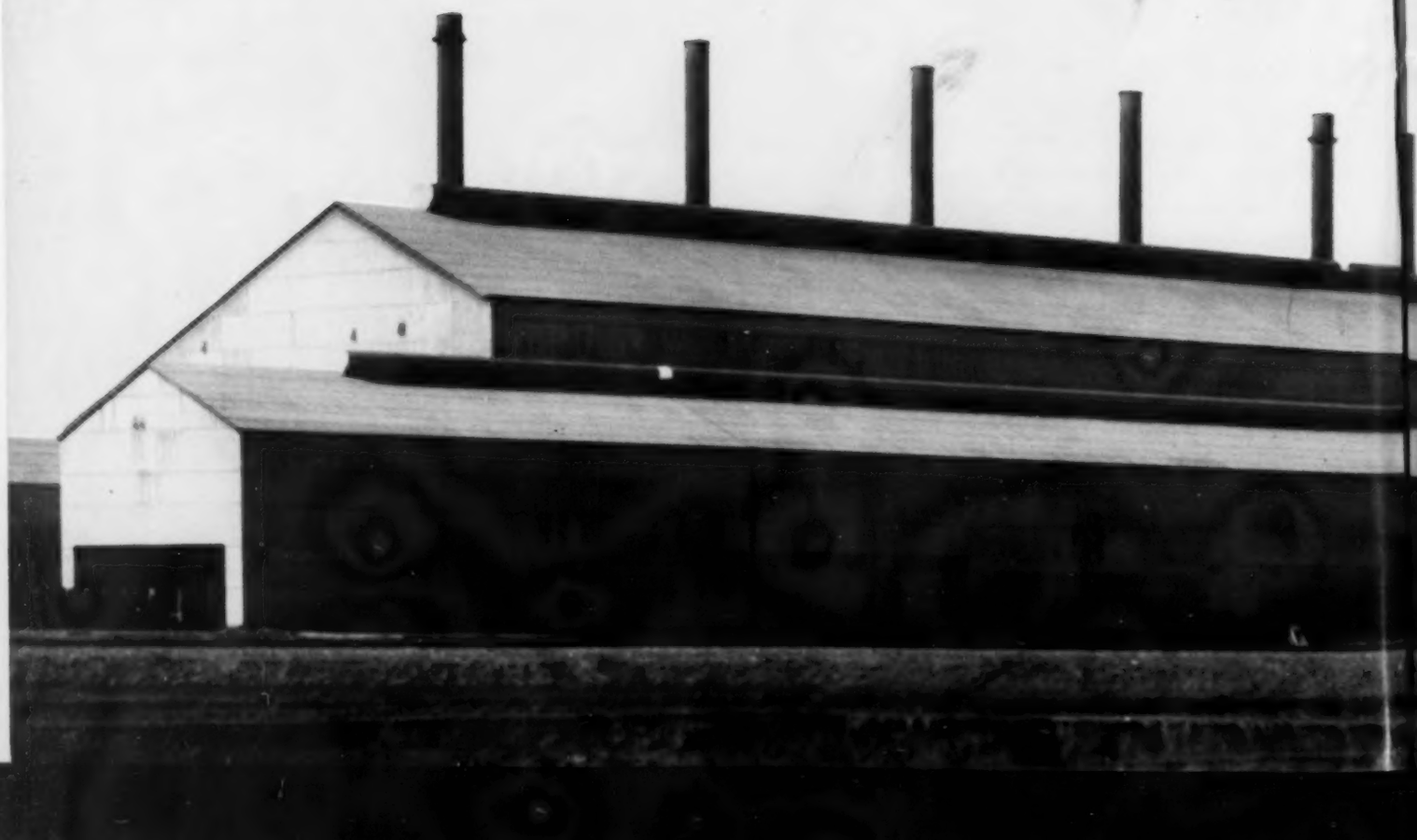
Write for your FREE copy of new Catalog No. 24 . . . the most comprehensive spray nozzle catalog ever produced.

For FAIRLESS WORKS

Koppers designed

FAIRLESS WORKS of United States Steel Corporation, located at Fairless Hills, Pennsylvania, is generally recognized as one of the best-designed steel mills in the world. Koppers Company is proud to have designed one of the major components of this plant—the steelmaking department.

Koppers designed the Fairless open-hearth shop and performed the principal construction thereof. This open-hearth shop is equipped with all of the most modern automatic equipment, controls and instruments. The open-hearths—nine in all—are housed in a main furnace building



that is 1,287 feet long and 88 feet wide. Each hearth, at sill level, is 60 feet long by 18 feet 6 inches wide, measured inside the brickwork. This gives a hearth area of 1,110 square feet.

The Fairless open-hearths are among the largest capacity furnaces of their type. Each furnace was designed for a heat size of 275 net tons; however, hearth size was made ample so that each furnace is presently rated at 290 tons. Rated annual steel-producing capacity for the nine furnaces is 2,200,000 net tons.

Designing and constructing open-hearths is just one way in which Koppers serves the steel industry. For any kind of metallurgical construction, you can count on Koppers. You are invited to consult with our Engineers and Management.

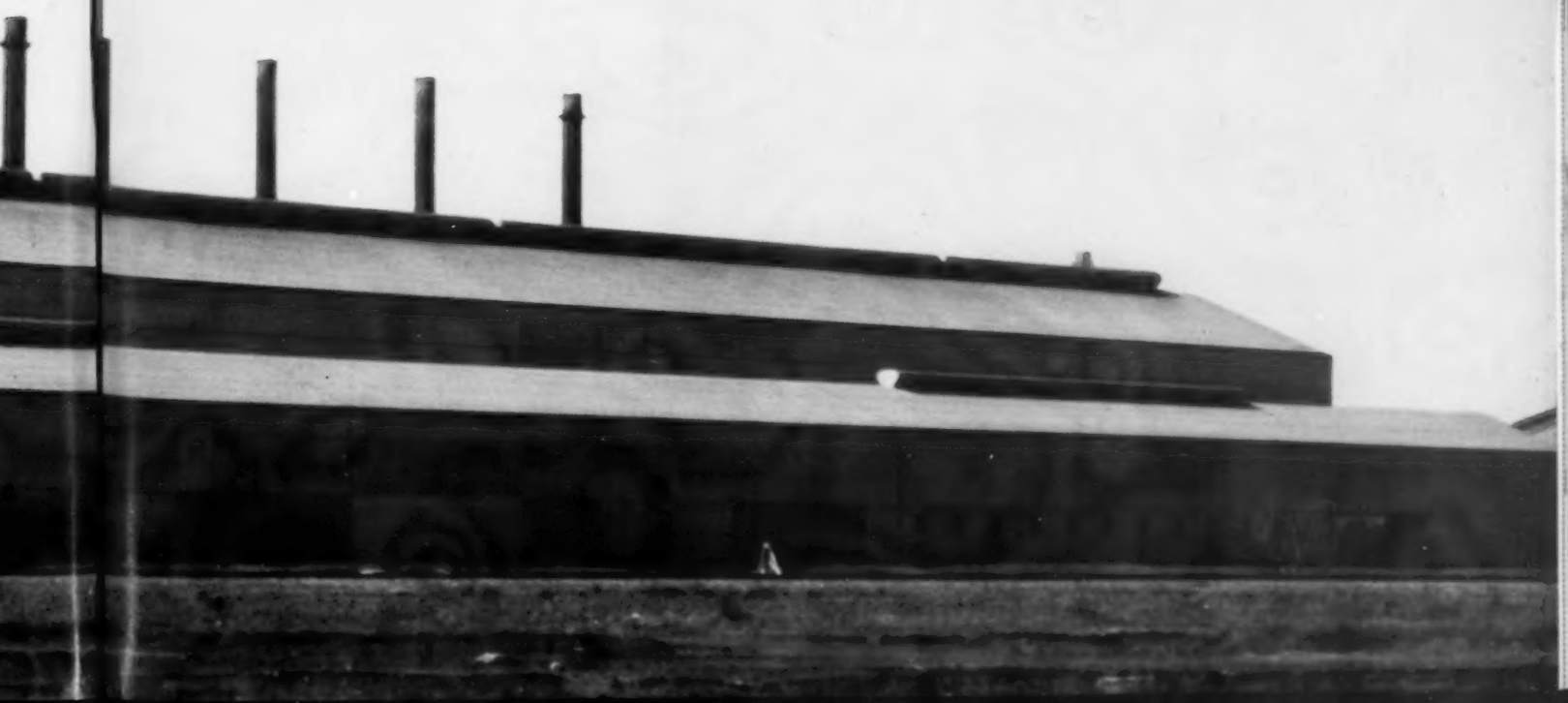
KOPPERS®

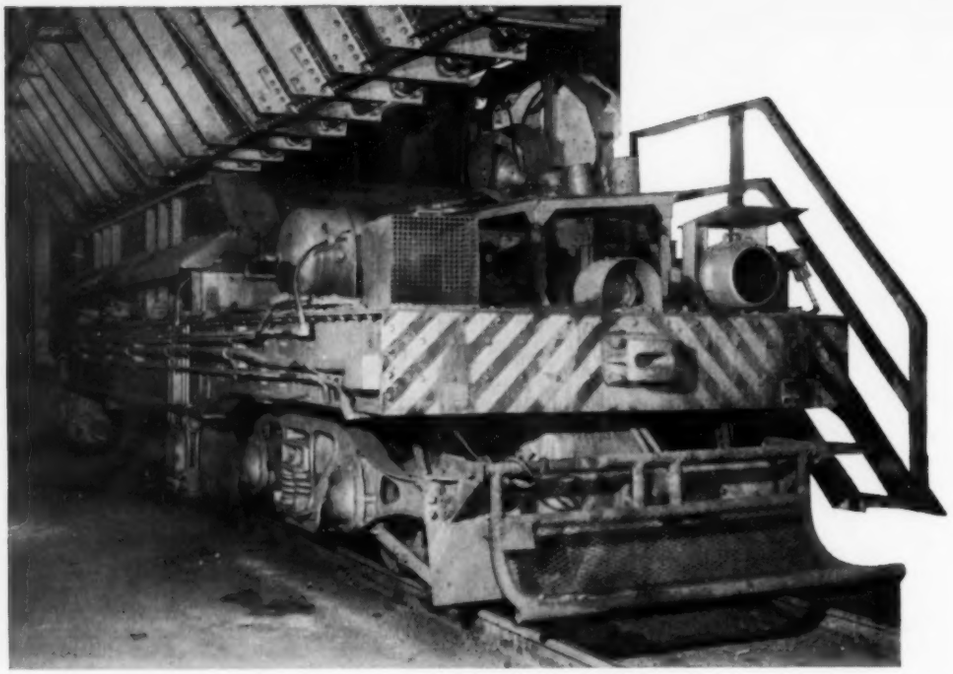
Engineering and Construction Division

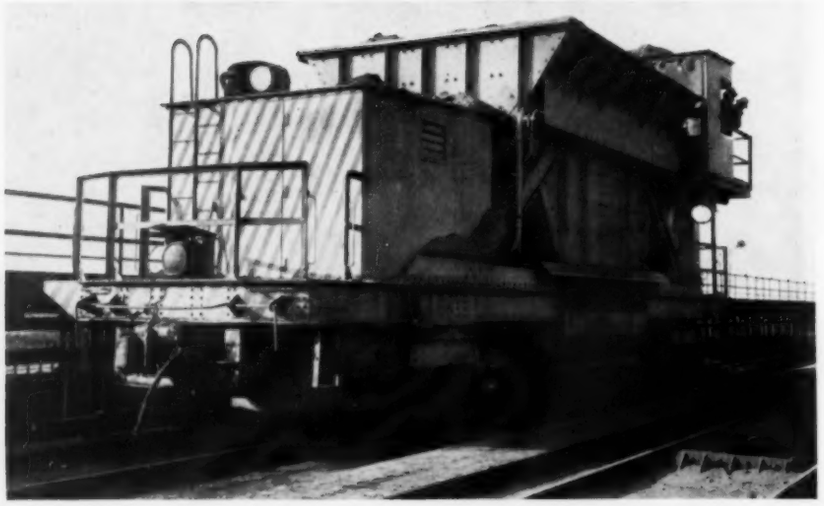
KOPPERS COMPANY, INC., PITTSBURGH 19, PENNSYLVANIA

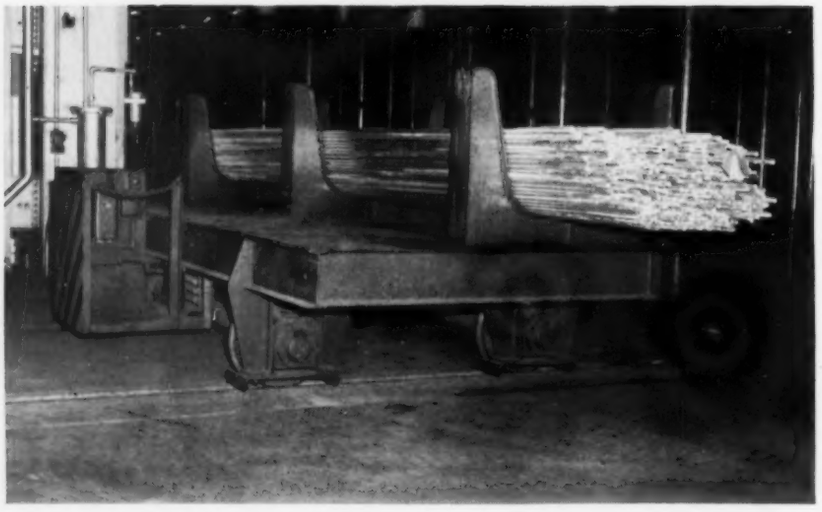
Open-hearth shop of Fairless Works, Fairless Hills, Pa. It houses nine open-hearths, designed by Koppers Company.

d this open-hearth shop









ATLAS CAR SERVES U. S. STEEL AT FAIRLESS

TOP — 40 TON SCALE CHARGING CAR shown in scale house. Car is of bottom dump, double compartment construction.

CENTER — 120 TON SIDE DUMP ORE TRANSFER in service on the highline.

BOTTOM — 32 TON FLAT CAR with cradles for pipe handling. Powered by a spring-driven cable reel and equipped with two operator platforms for double-end control.

THE ATLAS CAR AND MANUFATURING CO.

1140 IVANHOE ROAD **CLEVELAND 10, OHIO**

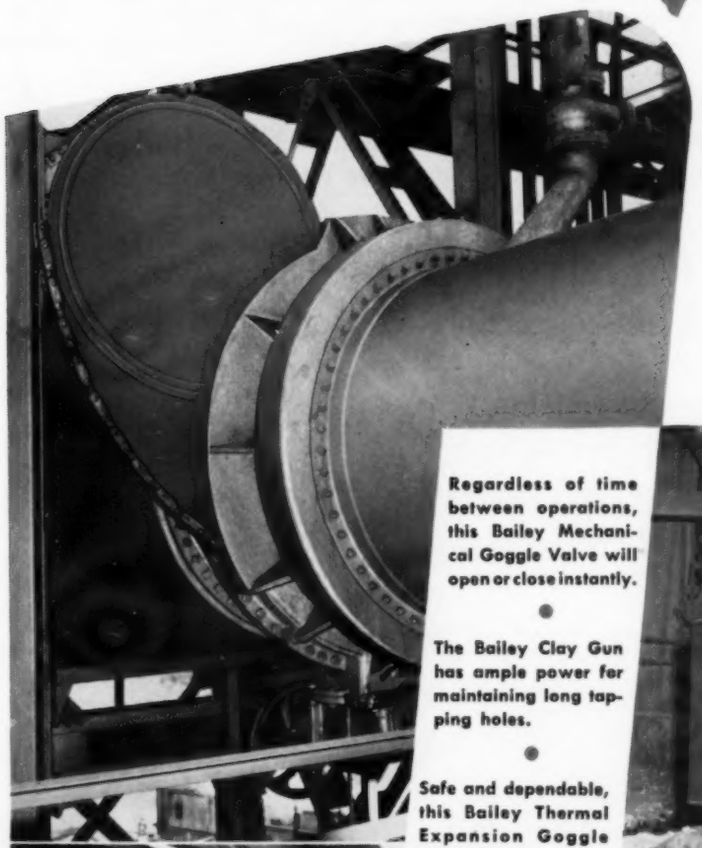
Bailey EQUIPMENT

contributes to

Safety and Efficiency

at the

Fairless Works



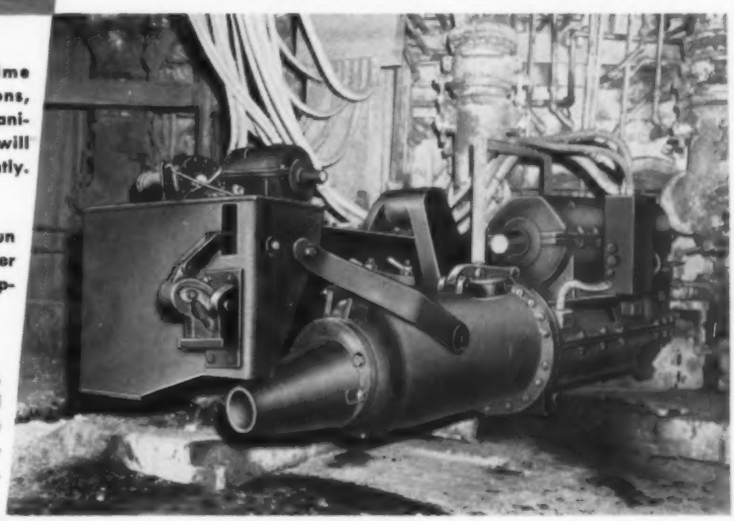
Regardless of time between operations, this Bailey Mechanical Goggle Valve will open or close instantly.

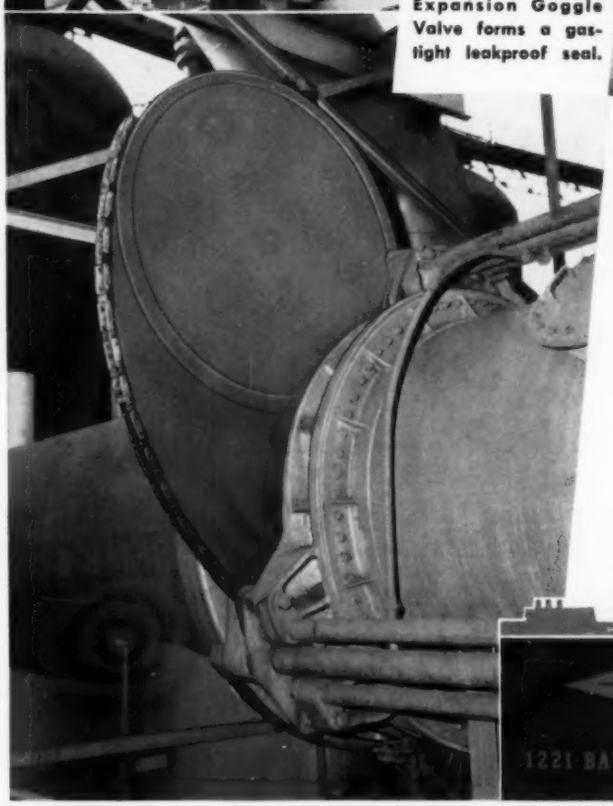
●

The Bailey Clay Gun has ample power for maintaining long tapping holes.

●

Safe and dependable, this Bailey Thermal Expansion Goggle Valve forms a gastight leakproof seal.





The dependability of Bailey Equipment plays a part in the safe, efficient operation of U. S. Steel's Fairless Works, just as it does in many other major steel plants. All Bailey Equipment is designed and manufactured with two basic considerations in mind—protection for men and equipment, and operation that is dependable and economical.

WILLIAM M. Bailey COMPANY

ENGINEERS

LEADERSHIP THROUGH QUALITY

1221 BANKSVILLE ROAD PITTSBURGH 16, PA

CONFIDENCE

. . . in our present Government and in the ability of our Engineering, Construction and Production men to out perform all others will go a long way toward holding our position as the world's leading Nation.

With our steel producing capacity already far ahead of any other country, it took a lot of confidence for U. S. STEEL CORPORATION to build the FAIRLESS WORKS, the largest ever constructed at one time. Also the best of judgment in selecting the Philadelphia region, the World's greatest industrial area.

When a temporary power supply of 12,000 K.V.A. was needed in 6 weeks in order to start construction, the job was given to PANGBORNE and it was completed on time. After that we were awarded the following additional major jobs, all direct contracts:

COMPLETE UNDERGROUND DUCT SYSTEM FOR
13.2 AND 2.4 K.V. POWER, TELEPHONE AND
SUPERVISORY SYSTEMS FOR ENTIRE PLANT

COMPLETE CABLE INSTALLATION FOR ABOVE SYSTEMS

FIVE INDOOR SUB-STATIONS FOR POWER SUPPLY TO
SHEET AND TIN MILLS

ROADWAY LIGHTING FOR ENTIRE PLANT

FIRE ALARM SYSTEM

PARKING LOT AND RAILROAD YARD LIGHTING

22 TON ORE BRIDGE FOR AMERICAN BRIDGE CO.

Nearly 40 years experience in this territory, doing all kinds of electrical construction, enabled us to meet the exacting schedules set by U. S. STEEL CORPORATION.

W.V. PANGBORNE & CO., INC.

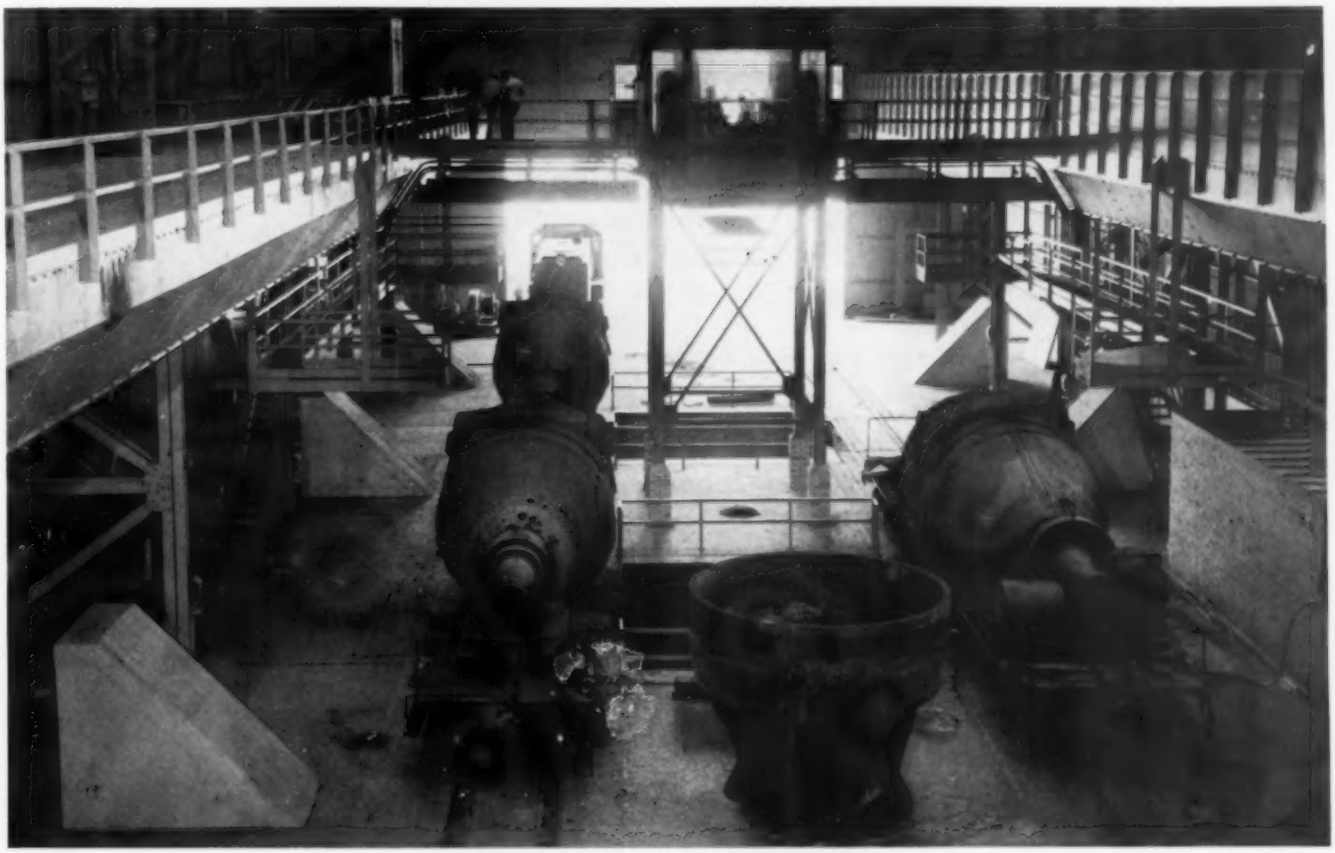
Philadelphia, Pa. — Trenton, N. J. — Camden, N. J.

TREADWELL

FIFTEEN MIXER TYPE HOT METAL CARS

IN SERVICE AT

FAIRLESS WORKS
UNITED STATES STEEL CORPORATION



200 NET TON MIXER CARS

AT

HOT METAL TRANSFER STATION

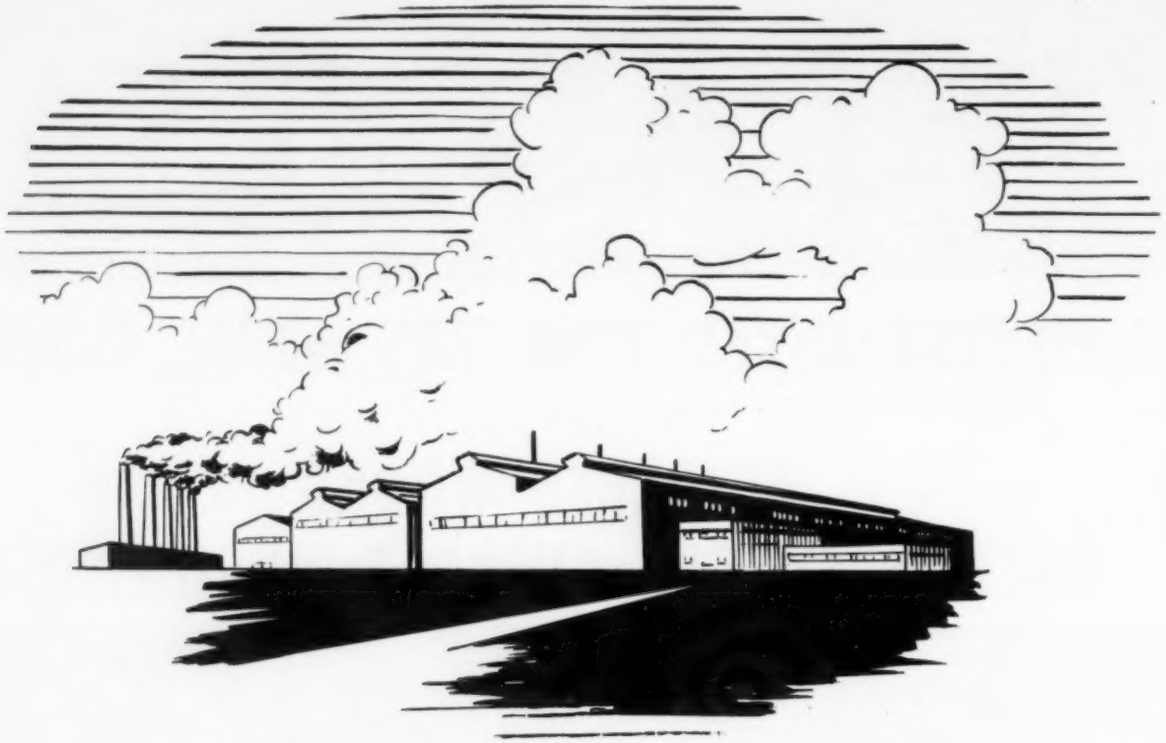
M. H. TREADWELL CO., INC.

208 S. LA SALLE ST.
CHICAGO 4, ILL.
CEntral 6-6784

140 CEDAR STREET
NEW YORK 6, N. Y.
WOrth 4-2344

1015 FARMERS BANK BLDG.
PITTSBURGH 22, PA.
ATlantic 1-2583

HEAD, WRIGHTSON, LTD., Thornaby on Tees, England



FORWARD WITH FAIRLESS...

During the past 36 years, the Fischbach and Moore organization has been privileged to participate in many of the key projects in American industry.

Never have we been more proud than when our services were called upon for electrical installations at United States Steel Corporation's new Fairless Works.

Fischbach and Moore's deepest satisfaction lies in its record of performance in serving U. S. Steel and other industrial leaders in their great steps forward.

FISCHBACH AND MOORE

INCORPORATED

ELECTRICAL CONTRACTORS

SINCE 1918

FROM COAST TO COAST *An organization that has to its credit every conceivable type of electrical installation.*

COMPLETE ORGANIZATIONS AT:

NEW YORK 17, N. Y.
226 East 41st Street

ATLANTA, GA.
244 Simpson Street N.W.

DALLAS 4, TEXAS
1717 Baylor Avenue

HOUSTON 2, TEXAS
Bankers Mortgage Bldg.

LOS ANGELES 4, CALIF.
646 North Beachwood Drive

SAN FRANCISCO 7, CALIF.
383 Fourth Street

CHICAGO 10, ILL.
1011 North Orleans Street

DETROIT 2, MICH.
101 Piquette

PITTSBURGH 3, PA.
81 South 19th Street

PHOENIX, ARIZONA
2246 West Jackson Street

SEATTLE 3, WASHINGTON
3201 Fremont Avenue

NEW ORLEANS, 19, LA.
315 North Broad Street

A Straight Shot of 925 FEET

At the NEW
FAIRLESS WORKS
of the United States Steel Corporation

A MORGAN
Horizontal-Vertical Continuous Rolling Mill reduces billets to merchant bar sections "straightaway" for 925 feet from furnace to cooling bed

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS RM-59
Rolling Mills—Wire Mills
Gas Producer Machines—Regenerative Furnace Control
English Representative
International Construction Co., 56 Kingsway, London, W. C. 2, England

View below shows a few of the many Quick-As-Wink Hydraulic Control Valves at U. S. Steel's Fairless Works.

at U.S. Steel's Fairless Works

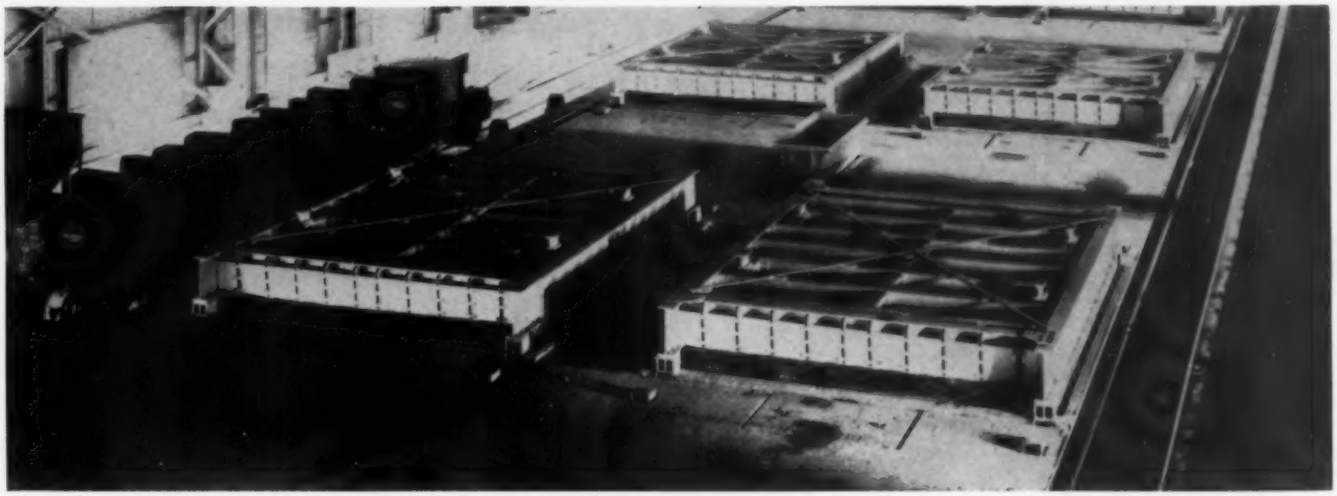
● Fast acting and thoroughly dependable, Quick-As-Wink Control Valves are widely used on important operations in the new Fairless Works. They will also be found in most other mills throughout the country, on hot mills, run-out tables, cold mills, coilers, and other heavy equipment. They're designed and built to meet the steel industry's most exacting requirements. The stainless steel plungers for instance, are chrome plated and polished to minimize wear. All parts are readily accessible; and maintenance — which consists mostly of the very occasional replacement of the packings — can be done easily without even disconnecting the piping. This avoids the necessity of returning the valves to the factory for servicing, or maintaining large standby inventories. Let us recommend the sizes and types that will meet your requirements. Or, write for Bulletin No. 531. It describes the complete line.

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

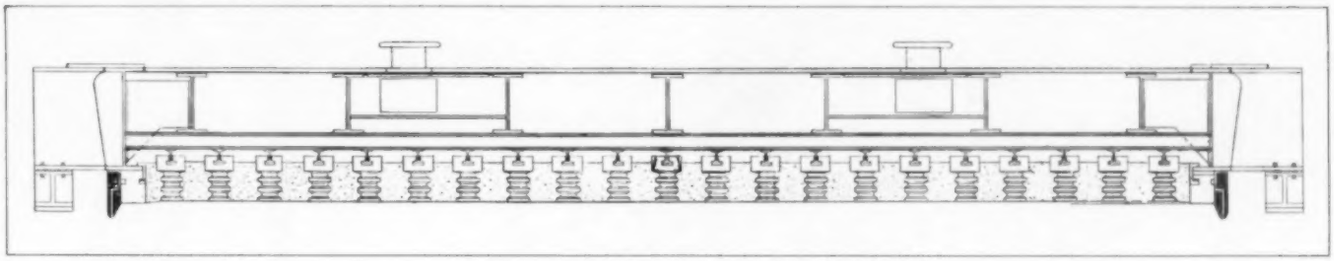
Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1925 East Pershing St., Salem, Ohio

A SOAKING PIT COVER....



....IS ONLY AS GOOD....



....AS ITS LINING....

and that's where **past** performance leads the way! AT THE UNITED STATES STEEL CORPORATION'S NEW FAIRLESS WORKS, you'll find four soaking pit covers (Lined with Special Super Ramtite No. 25) installed on Ramtite's reputation and past performance record.

The Ramtite Co. points proudly to the fact that there are more soaking pit covers lined with Ramtite Plastic Refractories than with all other plastic and castable refractories combined.

In the Steel Industry, as anywhere else, performance counts. We feel it is the reason for the ever-increasing use of Ramtite Refractories. They have proven themselves to be outstanding for rough-duty applications.

REFRACTORIES SPECIALTIES are our BUSINESS, not our sideline. Our experience in the field — over 30 years — qualifies us to help you with your specific refractory problem.

Contact your local Ramtite Representative for more information, or send us the coupon. ⟶

RAMTITE

PLASTIC • CASTABLE • GUNNING REFRACTORIES

THE RAMTITE CO., Div. of the S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send the items checked:

☐ Bulletin on Castable and Gunning Refractories
☐ Steel Plant Bulletin

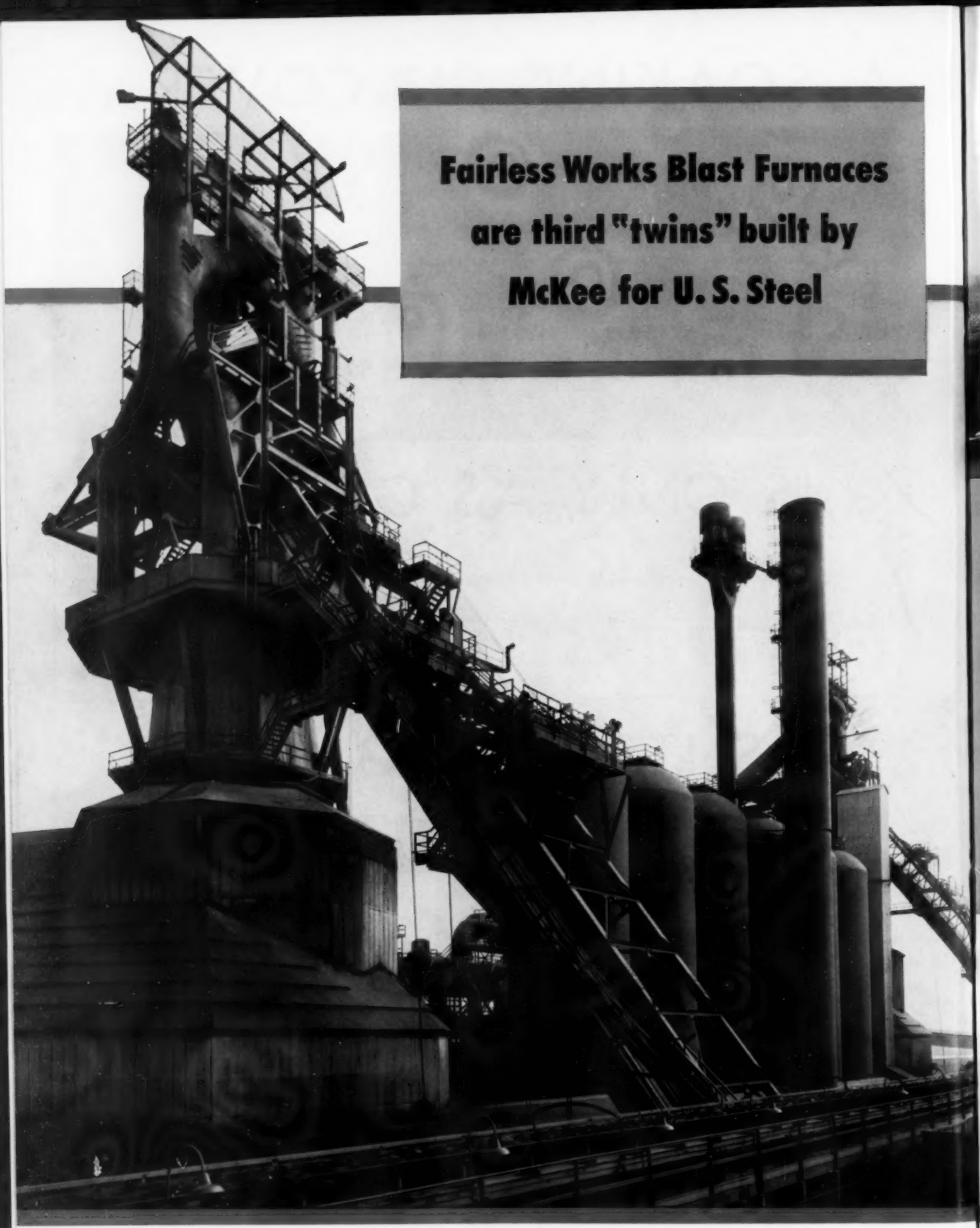
Company Name.....

Attn. Mr.....Title.....

Address.....

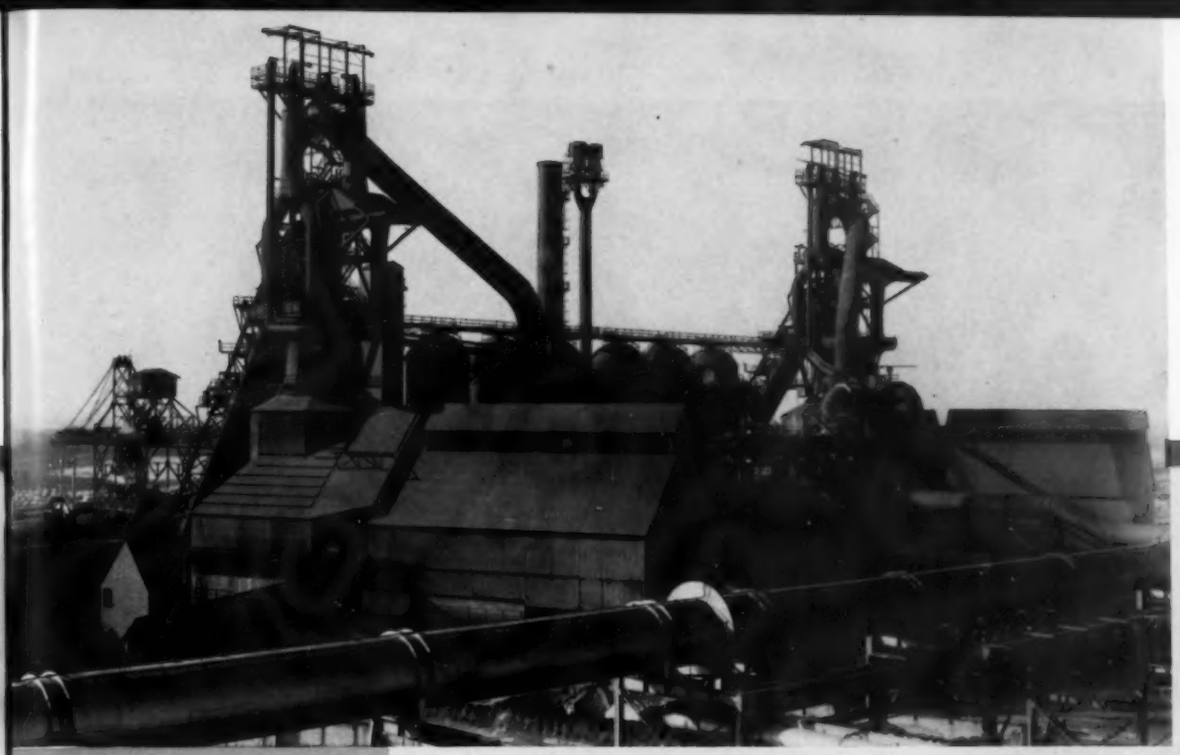
City.....Zone.....State.....

This is another in a series of advertisements depicting ways Ramtite Refractories serve the Steel Industry.



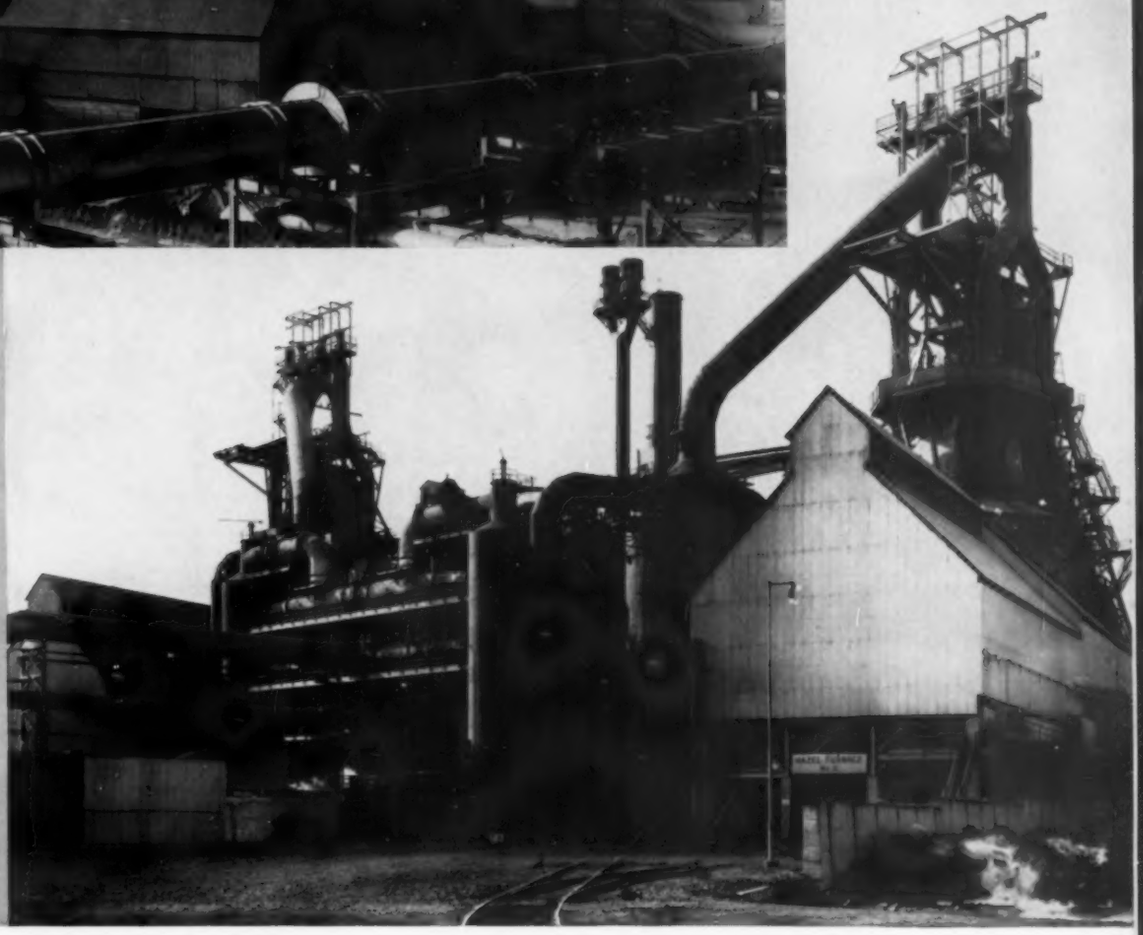
Fairless Works Blast Furnaces are third "twins" built by McKee for U. S. Steel

This view of the twin furnaces at Fairless Works shows the skip-bridge side with No. 2 Furnace in the foreground. No. 1 Furnace is almost hidden by the stoves, stack and conveyor belt from the coke ovens.



The single downcomer, characteristic trade-mark of McKee design, shows clearly on Fairless No. 1 Furnace at left. Clean gas main to the boiler house is in foreground.

The gas cleaning system is shown between the two cast houses. Number 1 Furnace is on the left. A corner of Number 2's slag pit is in right foreground.



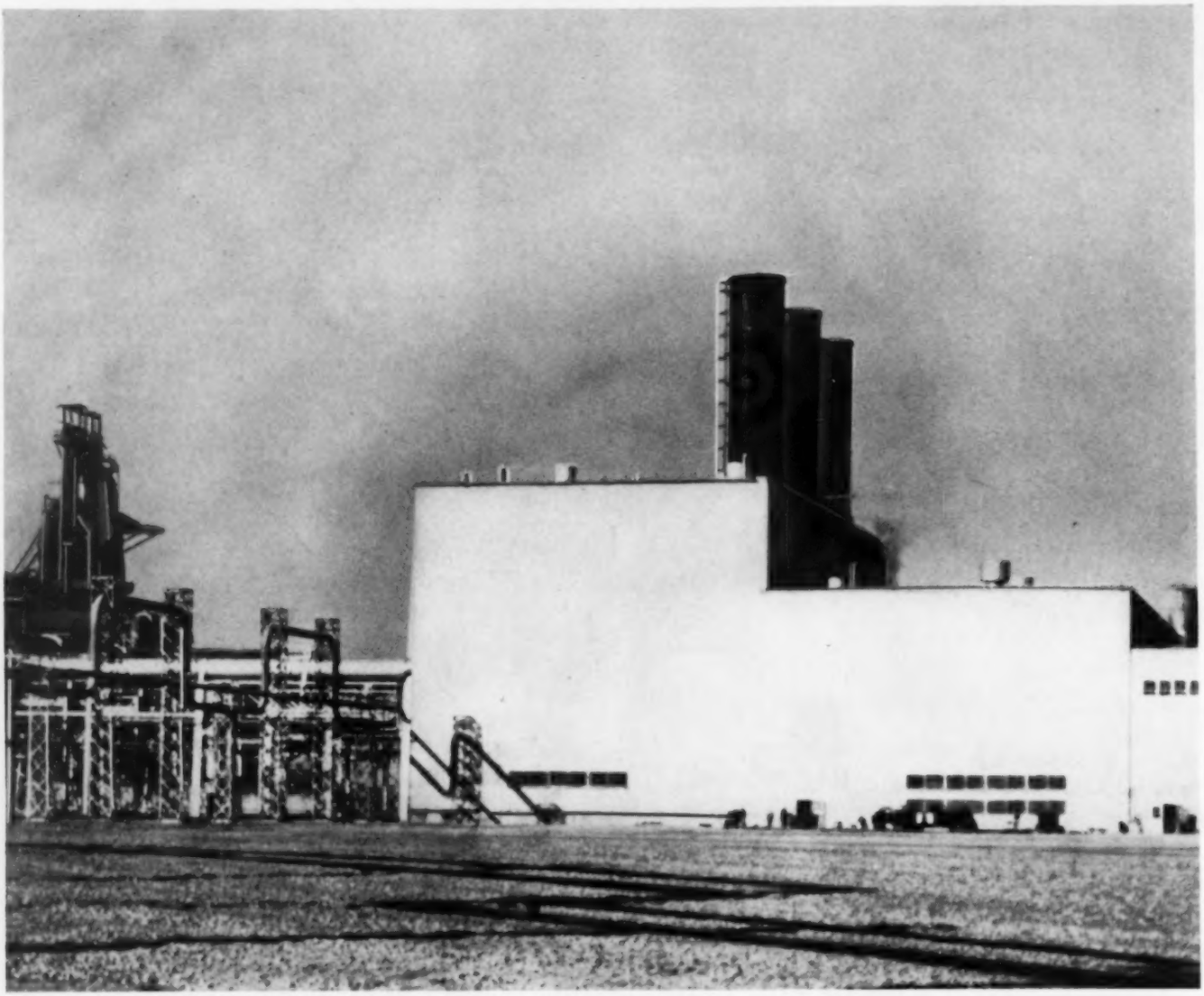
● Arthur G. McKee & Company have designed and constructed nine blast furnaces for United States Steel Corporation since 1940. A tenth furnace is nearing completion in Cleveland. All ten are 26 to 28-foot hearth-diameter furnaces.

The two furnaces at Fairless Works comprise the third set of blast furnace "twins" designed and constructed for United States Steel by McKee. The project includes stoves, gas cleaning system, cast houses, stock house and related facilities.

McKee Engineering Services

Arthur G. McKee & Company • Engineers and Contractors

Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York • Tulsa, Oklahoma • Union, N. J. • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 350 Bay St., Toronto



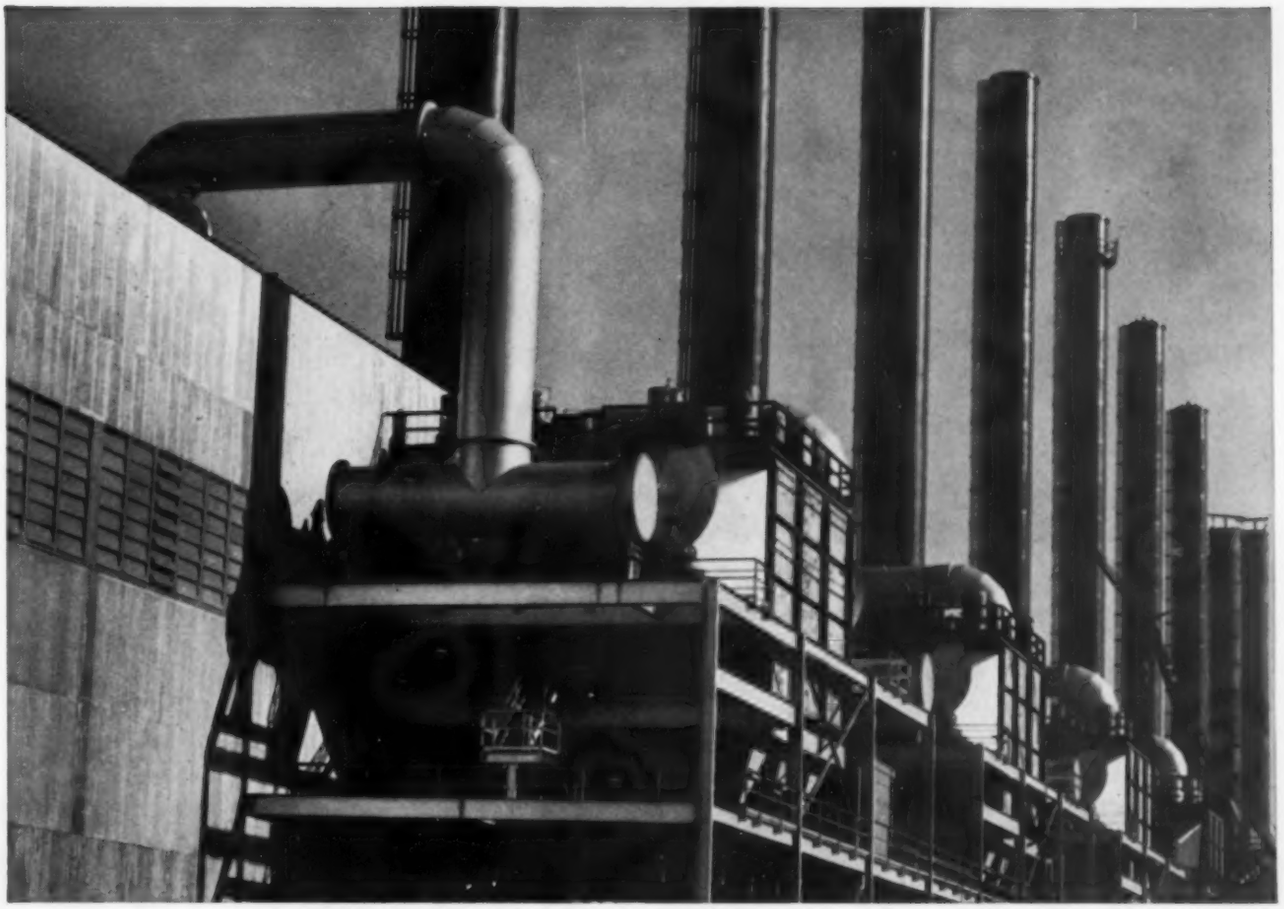
POWER PLANT
AND
BLAST FURNACE BLOWER HOUSE

FAIRLESS WORKS
UNITED STATES STEEL CORPORATION

DESIGN AND CONSTRUCTION
BY

GIBBS & HILL, INC.

CONSULTING ENGINEERS
DESIGNERS - CONSTRUCTORS
NEW YORK • LOS ANGELES



World's largest open hearth installation of Electrostatic Precipitators installed by Koppers at U.S. Steel's Fairless Works

Nine open hearths at the Fairless Works of U.S. Steel are equipped with Koppers Electrostatic Precipitators. Installed in pairs, these precipitators are minimizing smoke emissions in this industrial community.

No wonder Koppers Electrostatic Precipitators are doing such a magnificent job in reducing air pollution. They are designed and built to meet the exact requirements of the installation.

At our multi-million dollar research center, Verona, Pennsylvania, scientists and engineers are continuously engaged in creating the basis for technical leadership that has become a symbol of Koppers' service. At Koppers' new Mechanical Development Laboratories, Baltimore, continuous testing is conducted in close liaison with research activities at Verona.

Also, Koppers precipitators are designed, engineered, fabricated, erected and guaranteed under one contract by the Koppers Company. So consult Koppers when you have a gas cleaning problem . . . always ready to help you. No obligation, of course. For additional Koppers Electrostatic Precipitator information, mail the coupon below.

KOPPERS®

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with Fast's Couplings, American Hammered Industrial Piston and Sealing Rings, Aeromaster Fans, Gas Apparatus.

Engineered Products Sold with *Service*

ELECTROSTATIC PRECIPITATORS

KOPPERS COMPANY, INC., *Electrostatic Precipitator Dept.*
276 Scott St., Baltimore 3, Md.

Gentlemen: I am interested in an analysis and recommendations for my operation. I understand I am under no obligation.

Name.....

Company.....

Address.....

City..... Zone..... State.....

HAGAN
AIR-OPERATED CONTROLS
FUEL SAVING
HAGAN
RING BALANCE INSTRUMENTS

The primary purpose of every installation of Hagan Combustion Controls and Instrumentation is to save fuel.

Hagan equipment and Hagan methods have always been in the lead in implementing improved fuel burning practices. Hagan engineering skill has contributed materially to the success of many new methods.

Each unit of a Hagan System is built to give accurate and dependable service with minimum maintenance requirements. The complete series of components enables Hagan engineers to select exactly the right units for a fully coordinated system of Hagan Automatic Control and Instrumentation.

Hagan Ring Balance Instruments are the most versatile and reliable for providing the accurate records necessary in proper evaluation of performance. Standard designs are available for measuring and recording all the factors which affect combustion efficiency.

Is Our Business

The diversity of applications of Hagan equipment may be judged from these examples of successful installations.

Automatic control of blast furnace blower delivery, with automatic compensation for barometric pressure and air temperature.

Automatic combustion control, drum water level control and flow metering for boilers of all sizes and pressures, fired with all types of fuels, singly or in multiple.

Automatic controls and instrumentation for open hearth furnaces, soaking pits, heating furnaces of all types — including total heat input control for single or multiple fuel firing, fuel-air ratio control, furnace pressure control and automatic reversal.

Automatic control of fuel-air ratio for blast furnace gas burners on stoves and boilers.

Automatic control and metering for gas mixing stations on a ratio or Btu basis.

Flow metering for oxygen supply systems, with automatic correction for pressure and temperature variations.

Flow metering of natural gas, correcting automatically for pressure and temperature.

Metering and automatic controls for coke oven collector mains, exhausters, boosters, stacks and underfiring.

Whether for modernization or extension of existing installations, or for new construction, our engineers will be glad to suggest the best system to fulfill your requirements.

HAGAN CORPORATION

HAGAN HALL BUROMIN CALGON

HAGAN BUILDING • PITTSBURGH 30, PENNSYLVANIA

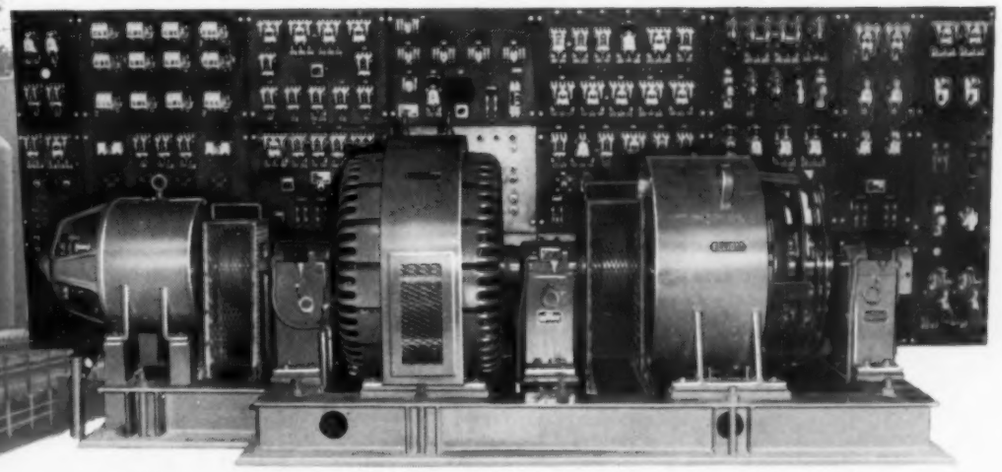
Boiler Combustion Control Systems • Ring Balance
Flow and Pressure Instruments • Metallurgical
Furnace Control Systems • Control Systems
for Automotive and Aeronautical Testing Facilities

Blast furnace skip

Each skip hoist is driven by two Elliott C-W 200-hp, totally-enclosed AISE standardized mill-type motors designed to work with a modern adjustable-voltage system providing maximum rates of acceleration and accuracy of stopping.

hoist drives by Elliott

AT U.S. STEEL'S FAIRLESS WORKS



This three-unit adjustable-voltage motor-generator set is one of two which furnish power for the skip hoist drive motors. The set consists of a 600-hp synchronous motor direct-connected to a 350-kw, 325-v d-c generator and a 50-kw, 250-v exciter. In the background are the Freyn control panels containing the various relays and contactors for the adjustable-voltage system.

Setting the pace for the steel plant of the future, the Fairless Works of the United States Steel Corporation has achieved world fame in its advanced planning and selection of equipment.

Among the 400-plus Elliott motors serving this great plant are the Elliott C-W mill motors driving the two blast furnace skip hoists. The drive for one skip is shown at left. The motor-generator set which supports these motors is shown above. This modern adjustable-voltage system not only provides fast and accurate operation but reduces mechanical maintenance.

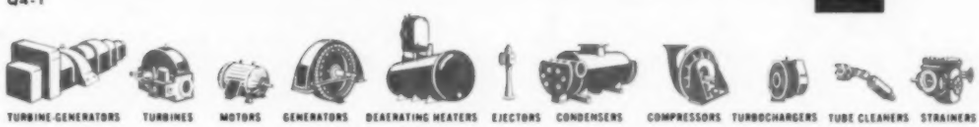
All other d-c motors in the blast furnace area are Elliott.

Elliott electrical equipment has served the steel industry well for the past half-century and more.

For details on steel mill electrical equipment consult your local Elliott field engineer or district office or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

Q4-1

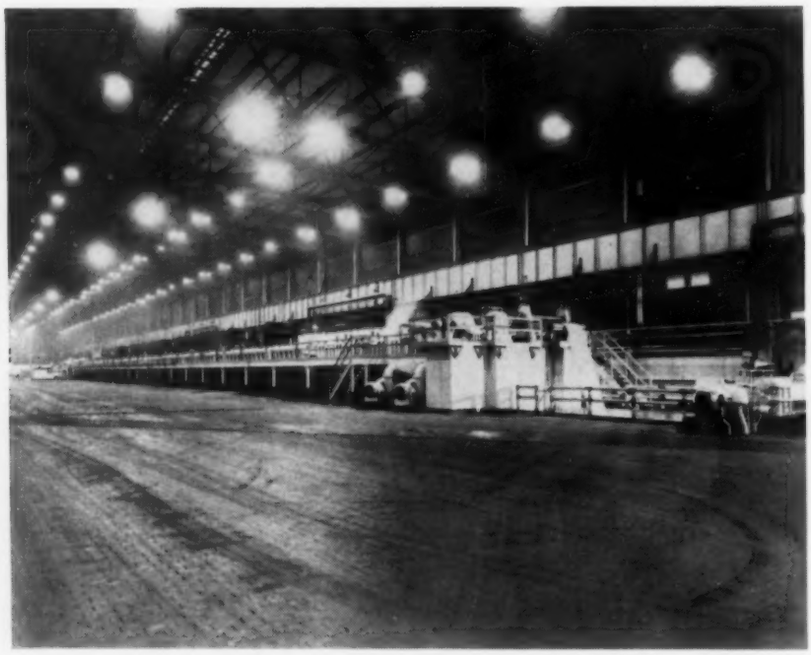


Chemsteel CASEBOOK

ACID-ALKALI-PROOF CONSTRUCTION
CHEMSTEEL CONSTRUCTION COMPANY, INC.

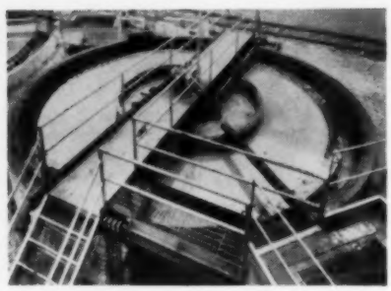
Acid-Alkali-Proof Construction News of Interest to Metal Working Men

CHEMSTEEL PROTECTS U.S. STEEL!



Continuous Pickling Line and Acid-Proof Flooring

Waste Pickling Solution Tank



Flash Mixer

Acid doesn't stand a chance at U. S. Steel's new Fairless Works. The 80″ Continuous Pickling Line, the Flash Mixer, the Waste Acid Holding Tanks and other equipment subject to acid attack have been completely protected from such attack by Chemsteel Construction Company, Inc.

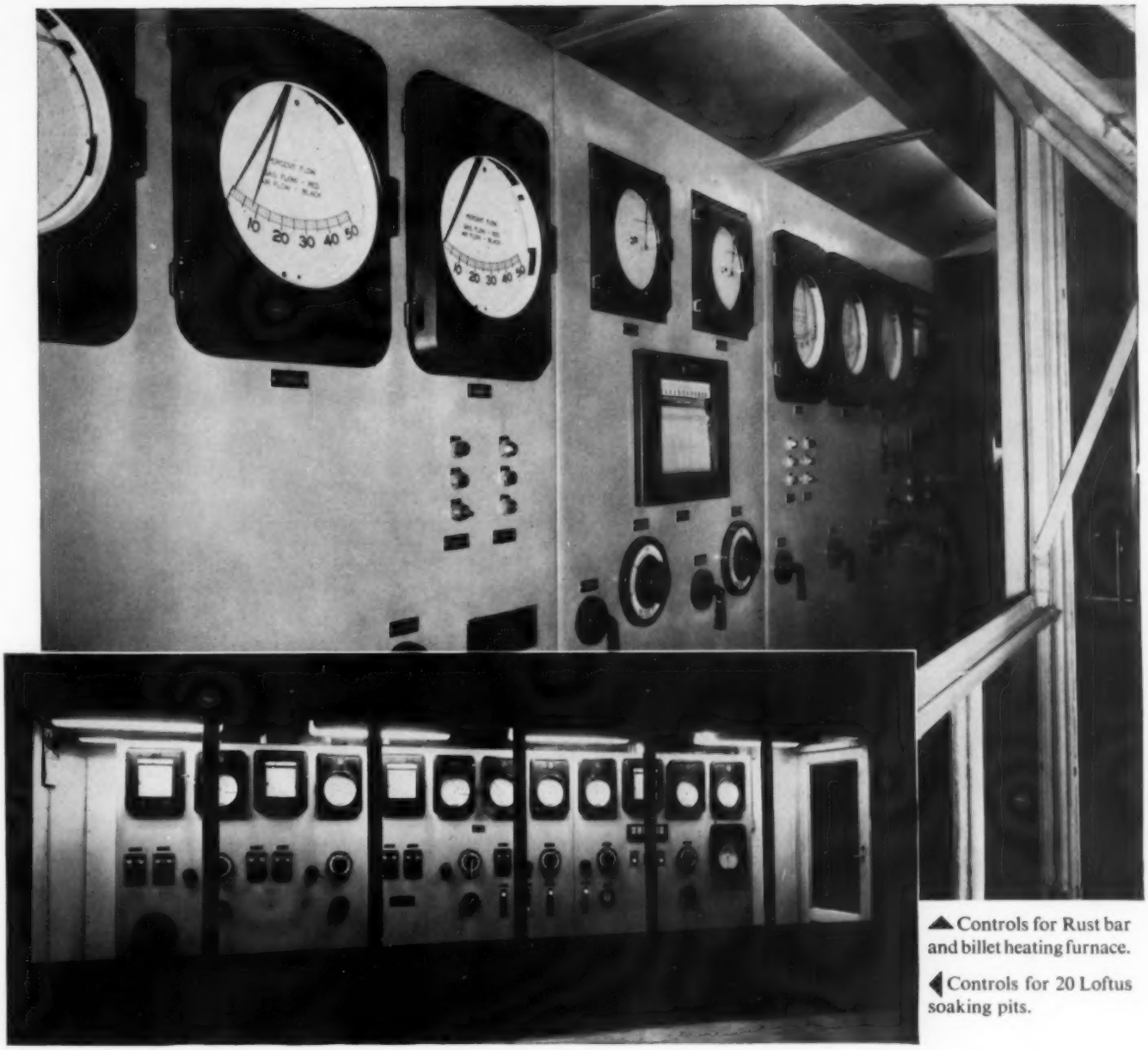
Chemsteel crews, working with J. M. Foster Co., Inc., installed acid brick sheathing over rubberlined steel of the pickle line; lined two 50′ diam. by 16′6″ deep Pickle Liquor Storage Tanks with 4″ acid brick for Dravo Corp.; and installed 4″ acid brick sheathing over glass cloth reinforced asphalt membrane — also for Dravo — to protect the Flash Mixer.

The 80″ Continuous Pickle Line consists of a four-section acid tank, 336′ by 10′2″ by 6′1″ deep (I.S.), lined with 12″ acid brick; and a one-section wash tank, 37′ by 10′2″ by 4′ deep (I.S.), lined with 8″ acid brick. The Pickle Liquor Storage Tanks (weak acid) are both 50′ diameter and 16′6″ deep. The Flash Mixer is 22′8″ in diameter and 12′6″ deep.

Chemsteel also handled piers, trenches and sumps; almost 25,000 square feet of acid-proof flooring under the pickle line, in the electrolytic tinning line basement and in the acid tunnels; and other miscellaneous installations to protect various facilities in the Sheet and Tin division at U. S. Steel's Fairless Works.

Find out how you, too, can profit from Chemsteel specialized acid-alkali-proof construction services. Write for details today!

CHEMSTEEL CONSTRUCTION COMPANY, INC., 204 CHEMSTEEL BLDG., PITTSBURGH 32, PA.



▲ Controls for Rust bar and billet heating furnace.

◀ Controls for 20 Loftus soaking pits.

ASKANIA supplies four combustion control installations at the Fairless Works, United States Steel Corporation

Steel men at the Fairless Works of the United States Steel Corporation, Fairless Hills, Pa., selected the control installations above to control a Rust bar and billet heating furnace and a battery of 20 Loftus soaking pits. Not illustrated are other controls for Wilputte coke ovens and Ingersol-Rand blast furnace blowers.

When steel men need combustion controls they choose Askania—just as they have been doing for twenty years. They know that Askania controls are common-sense controls—simple and sturdy—designed and built to do the hardest jobs for the longest time. They know that Askania controls make their job easier and their results better. They know they can get fine controls for their combustion needs—pressure, flow, fuel and air proportioning, and furnace reversal controls—tools that make more steel and better steel for less money.

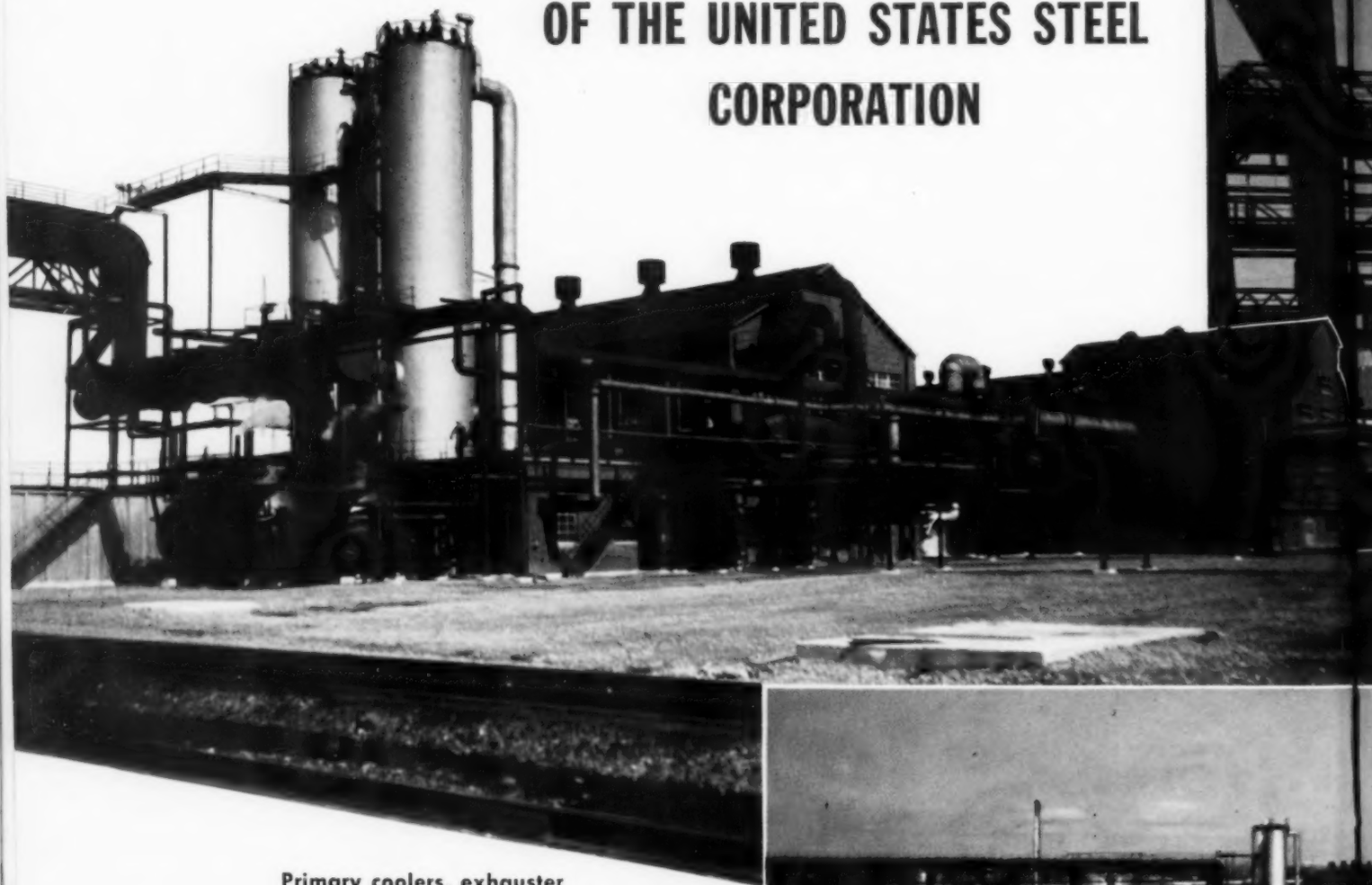
Askania will solve your combustion control problems—Write for Bulletin 139

ASKANIA REGULATOR COMPANY
246 E. Ontario Street, Chicago 11, Illinois
Subsidiary of General Precision Equipment Corp.

a complete

WILPUTTE coke plant

AT THE NEW FAIRLESS WORKS OF THE UNITED STATES STEEL CORPORATION



Primary coolers, exhauster building and ammonia recovery plant.

WILPUTTE

Two 87 oven batteries of Wilputte underjet ovens.

General view of coal chemical recovery plant.

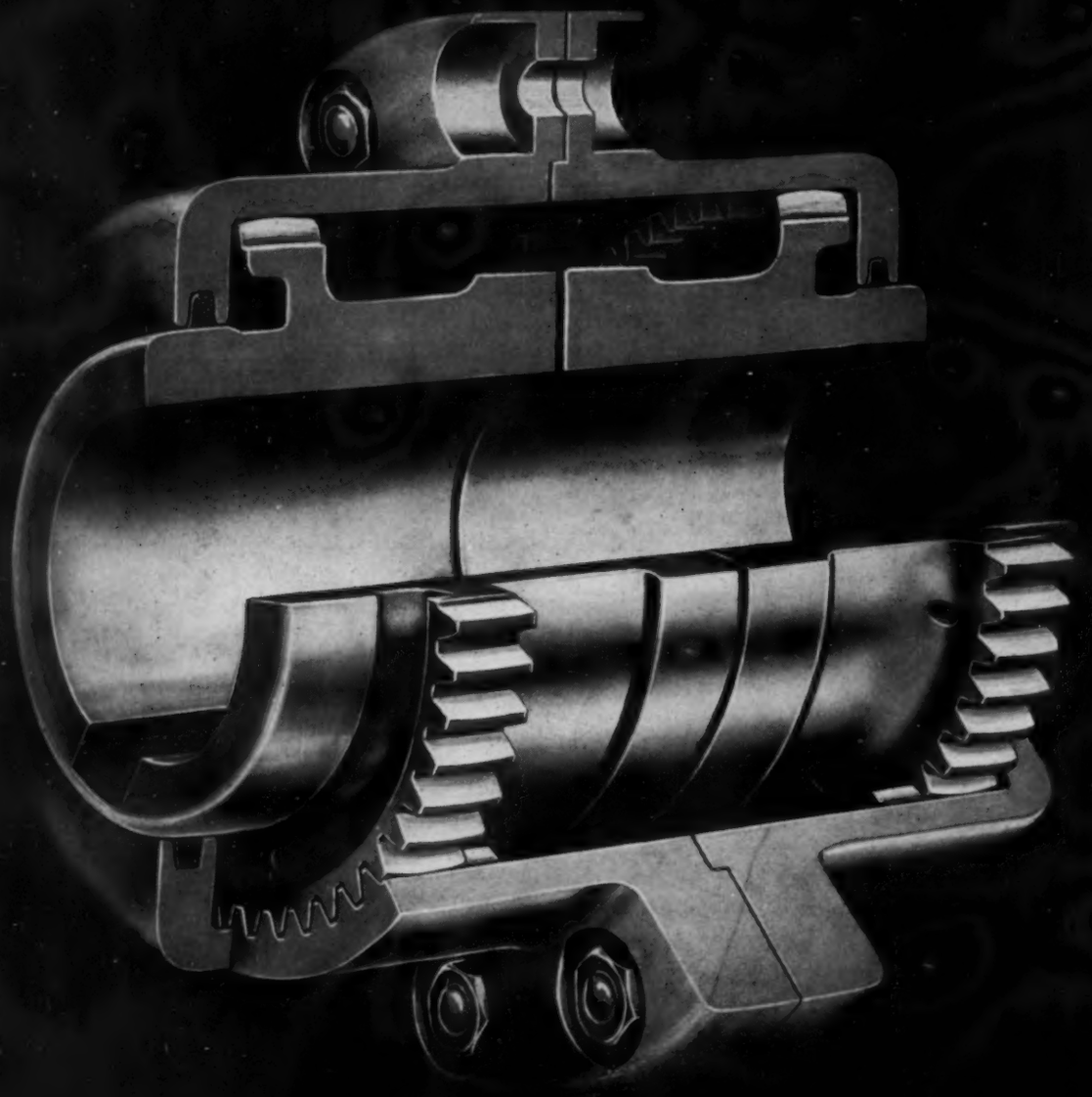
COKE OVEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 RECTOR STREET • NEW YORK 6, N. Y.

Allied Chemical

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

New Fairless Works billet mill gets extra bearing capacity in same space

with TIMKEN® Balanced Proportion Bearings

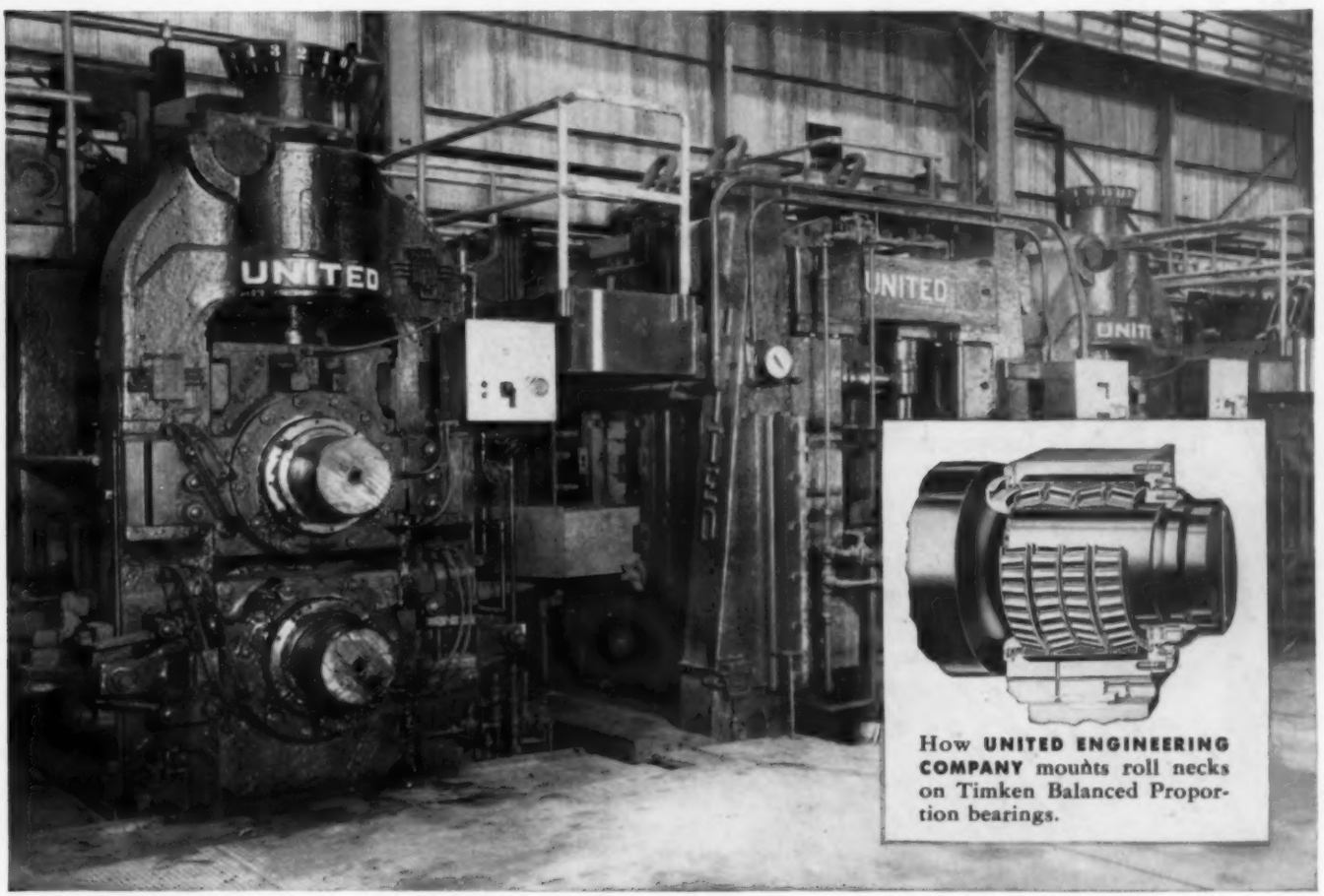
HERE'S another mill equipped with Timken® Balanced Proportion bearings—a new 10-stand billet mill at U. S. Steel's Fairless Works. These bearings are among the more than 3000 Timken tapered roller bearings used in the Fairless Works!

Timken Balanced Proportion bearings have load ratings up to 40% higher than the same-size bearings in the older design. In some mills, they increase bearing life expectancy almost three times! Moreover, Timken Balanced Proportion bearings make possible a 50 to 60% increase in neck strength which means greater rigidity and higher rolling precision.

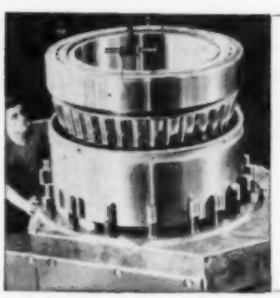
To make these truly significant improvements in an already good bearing design, Timken Company engineers made an exhaustive study of steel mill bearing requirements. Ultimately they developed the Balanced Proportion design. Rollers are longer, permitting higher loads—and thinner, permitting larger bores and stronger roll necks. Timken Balanced Proportion bearings have now been applied to numerous types of mills.

Timken tapered roller bearings are a sure sign of quality on the steel mill machinery you buy or build. Always look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How **UNITED ENGINEERING COMPANY** mounts roll necks on Timken Balanced Proportion bearings.



ROLL NECK BEARING ENGINEERING SERVICE

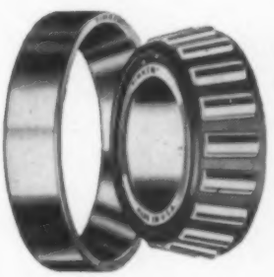
Our field and service engineers have had years of experience with problems of roll neck bearing design and operation. They'll help you select bearings and design mountings.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis Timken steels.

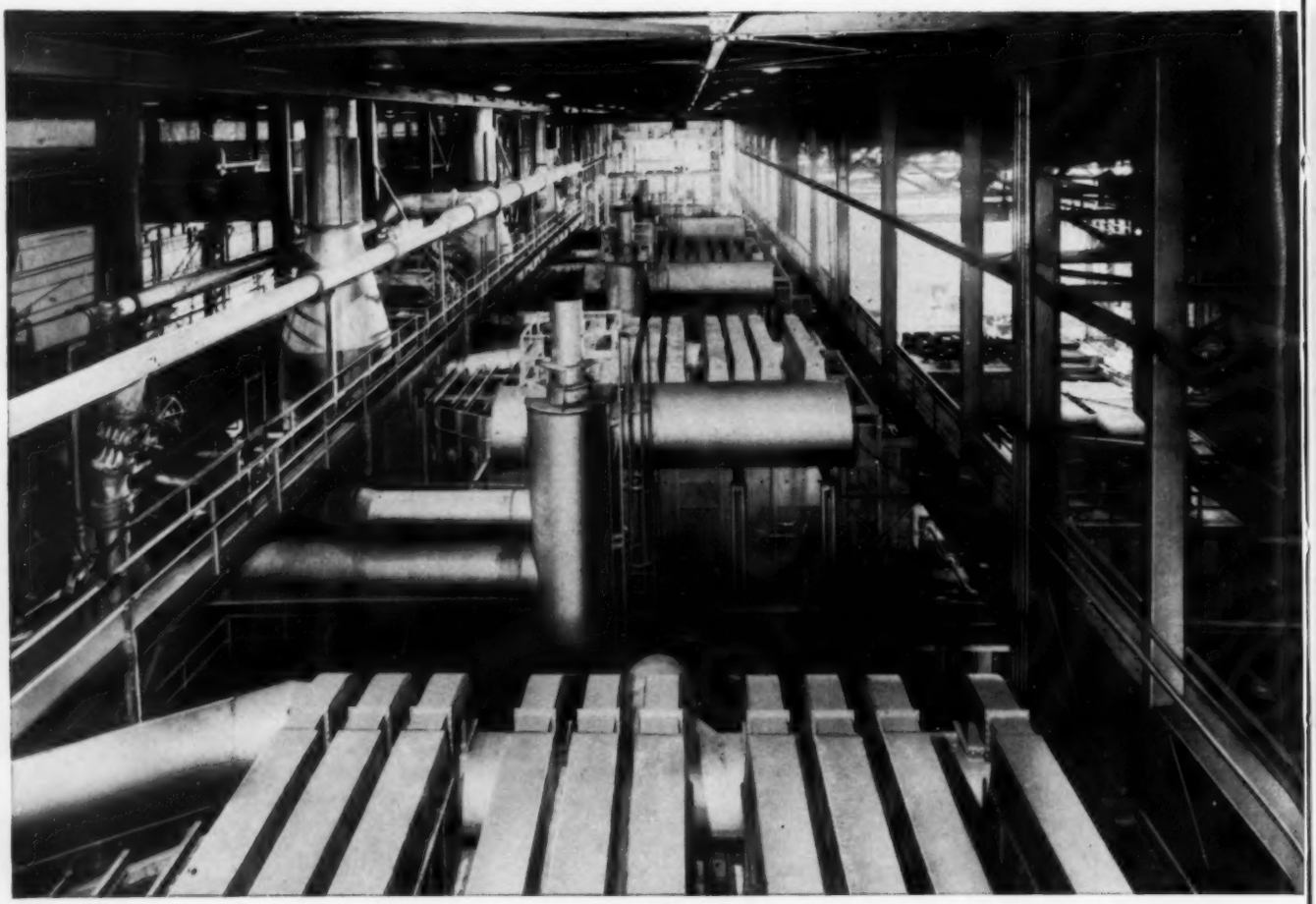
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



HAZEN FURNACE RECUPERATORS.



Hazen Metallic Recuperators installed above 4 new Slab Reheating Furnaces at U.S. Steel Corp., Fairless Hills, Pa.

the only 100% American Metallic Recuperator

- **Entirely made in U.S.A. All inner and outer tubes made of Stainless Steel.**
- **This application takes advantage of the natural upward flow of flue gases.**
- **Less stack draft is required.**
- **Increased preheat . . . due to availability of a larger percentage of flue gases at higher temperatures.**

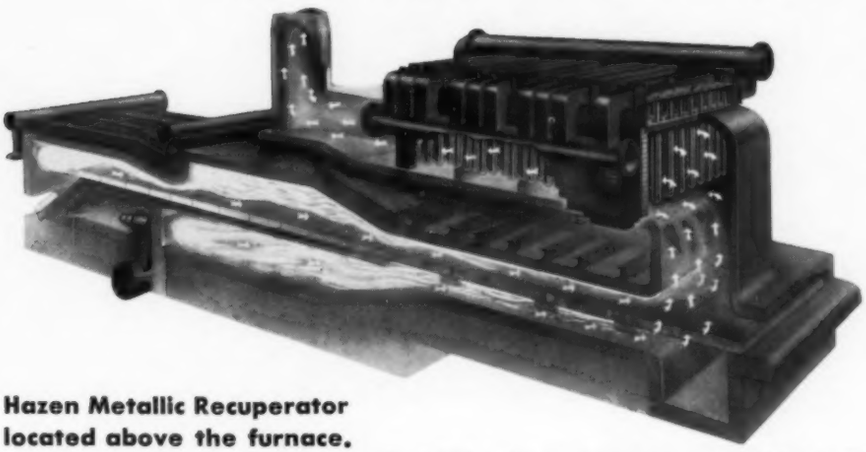
Consult us about improving the production and economy of <u>your</u> furnace operations

RS...at U.S. STEEL-FAIRLESS WORKS

The FIRST installation of NEW Furnaces with the Recuperator ABOVE the Furnace . . . *to take advantage of*

What Comes Naturally

in the flow of flue gases from the furnace to the recuperator



Hazen Metallic Recuperator located above the furnace. Greater furnace economy is derived when space permits this position.

CONVENTIONAL APPLICATIONS
RESIST
THE NATURAL UPWARD FLOW OF GASES

IMPROVED APPLICATIONS
ASSIST
THE NATURAL UPWARD FLOW OF GASES

- **Economies in initial cost . . . by reducing the required amount of excavating and furnace foundation . . . by reducing the length of flue ordinarily required from furnace to stack.**
- **Recuperator, flue and stack may be supported from steel work independent of the furnace bindings.**
- **Walkways may be provided around the recuperator for convenience of inspection and cleaning.**
- **Recuperator may be applied above an existing furnace with a minimum loss in outage time.**

HAZEN ENGINEERING COMPANY

PARK BUILDING • PITTSBURGH 22, PA.

TELEPHONE: COurt 1-7030

8 MILES OF PIPE INSTALLED AT U.S. STEEL'S FAIRLESS WORKS BY

CHAS. F. SMITH & SONS, INC.

Approximately 8 Miles of 102", 72", 60", 54", 48", 42", 36", and 30", of prestressed concrete and welded steel water lines were laid by Chas. F. Smith & Sons, Inc. at the Fairless Works of U. S. Steel.

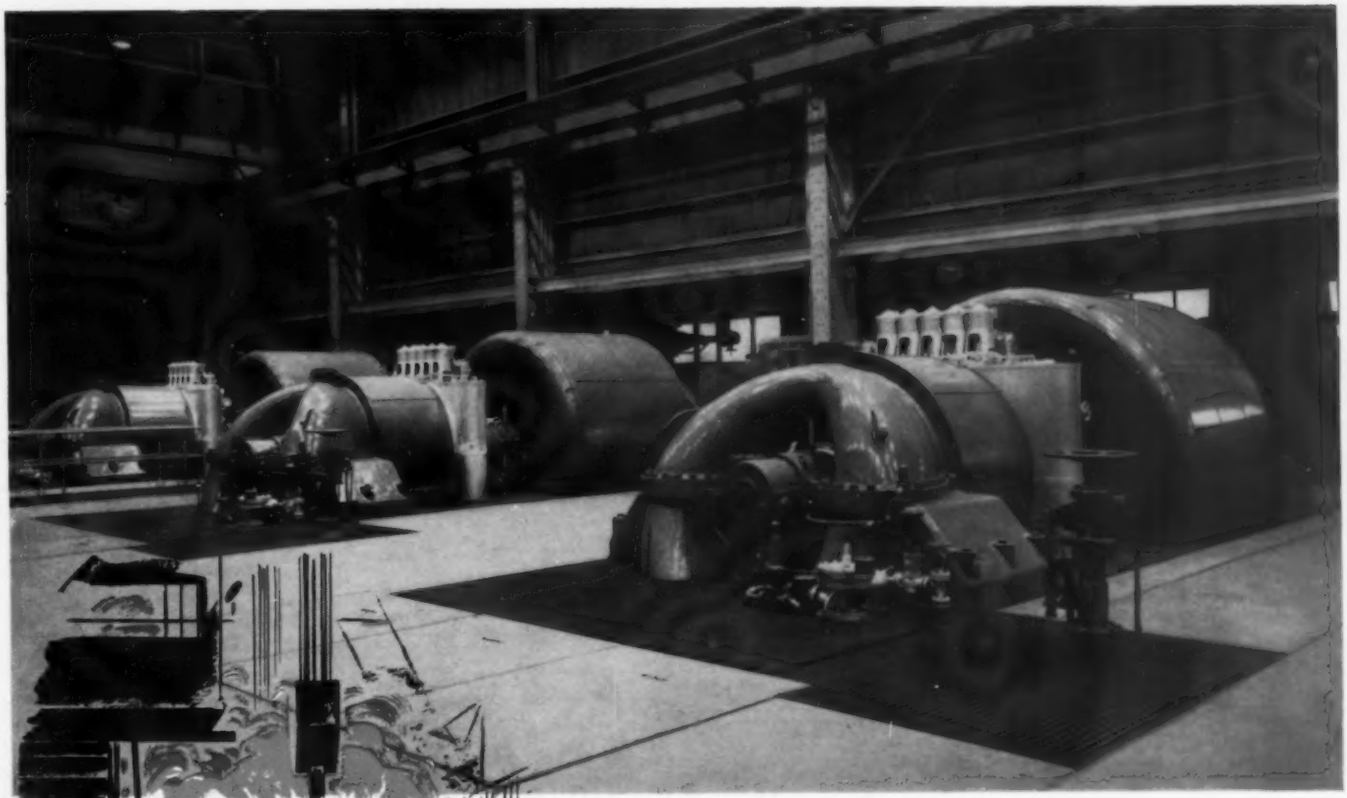
SPECIALISTS IN THE INSTALLATION OF LARGE DIAMETER WATER AND SEWER LINES

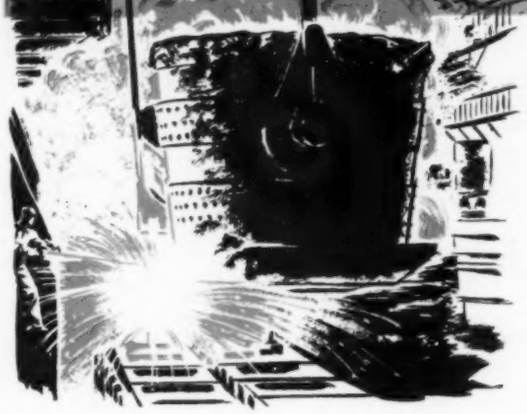
CHAS. F. SMITH & SONS, INC.

CONSTRUCTION CO.

118 SPIREA DRIVE, DAYTON, OHIO · WALNUT & BIRCH STS., KENNETT SQUARE, PA.

375,000 cfm
for U. S. Steel's Fairless Works





United States Steel's new Fairless Works at Fairless Hills adds another 2,200,000 ingot tons to America's steel-producing capacity. Its two blast furnaces have an annual capacity of 1,134,000 tons of iron—and its nine open hearth furnaces are capable of producing 2.2 million tons of steel per year. Also, rolling facilities are provided for cold rolled sheets, hot rolled sheets, steel pipe, merchant bars and tin mill products.

Over 45,000 hp of I-R Blowers supply ALL BLAST FURNACE AIR

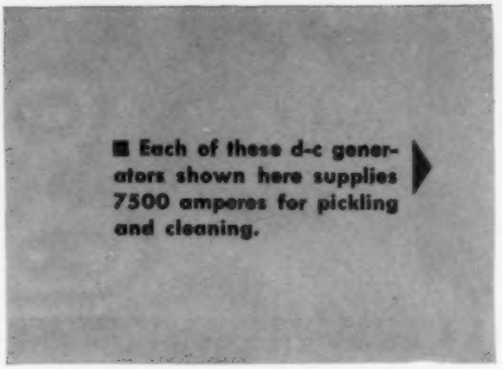
In the photo above, you see the three, huge blast-furnace blowers at U. S. Steel's new Fairless Works. Each of these Ingersoll-Rand five-stage centrifugal compressors supplies 125,000 cfm against 35 psig, and is driven by a 15,750 hp I-R steam turbine. They will normally operate on 850 psi steam at 900°F.

The steam boilers in the power plant are supplied by five Ingersoll-Rand 8-stage CHTB boiler-feed pumps. Fifteen I-R gas jets mix air and natural gas to provide supplementary fuel of correct BTU value.

When it comes to steel mill blowing and associated power-plant equipment, it pays to take advantage of Ingersoll-Rand's specialized experience in this field.

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS
CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES 12-79



■ Each of these d-c generators shown here supplies 7500 amperes for pickling and cleaning.

E.P. Supplies

Direct Current for U. S. Steel's

Fairless Works

■ **110,200 D-C Amperes for Electrolytic Tinning**

■ **49 Battery-Charger Circuits for Electric Trucks**

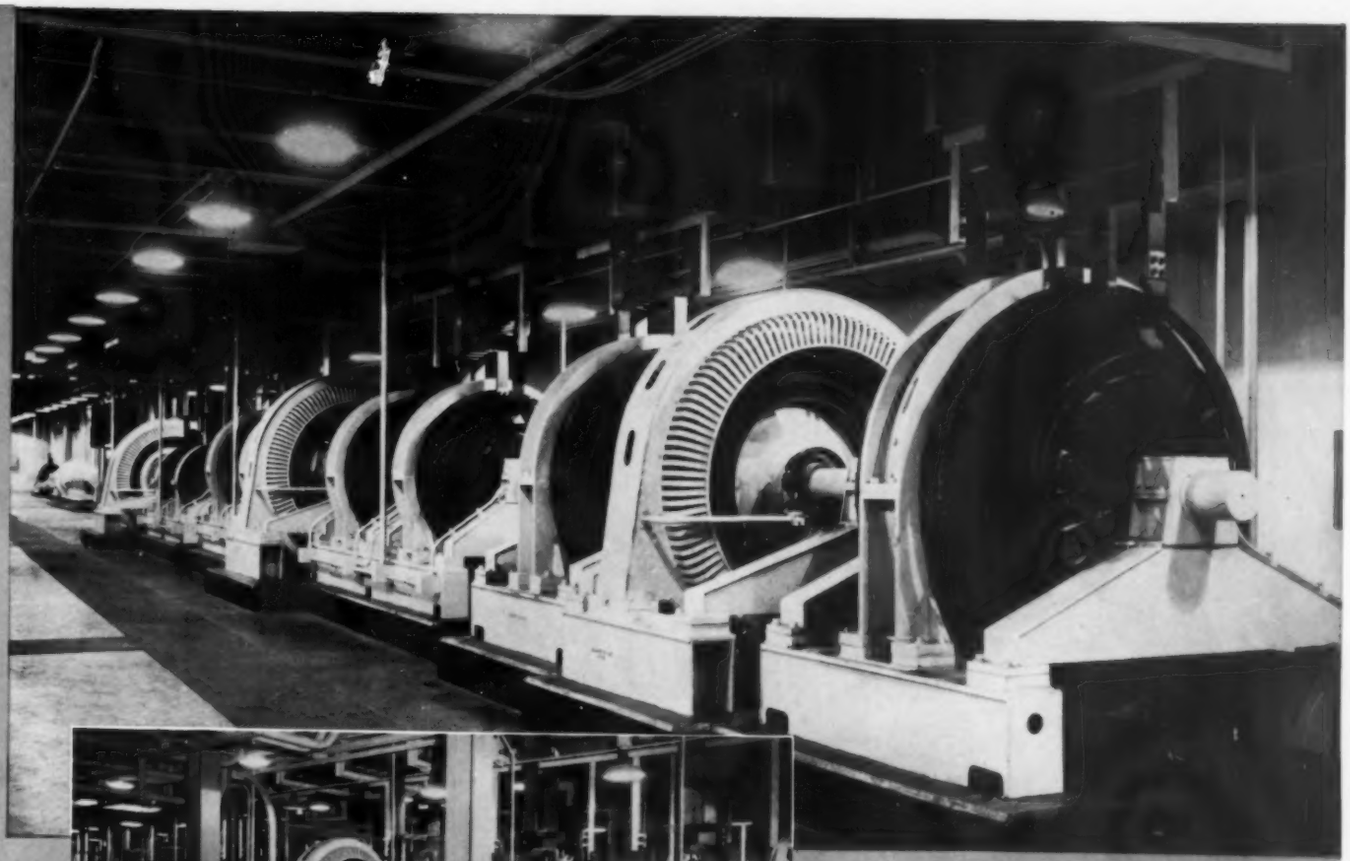
■ **126 KW for Special D-C Requirements**

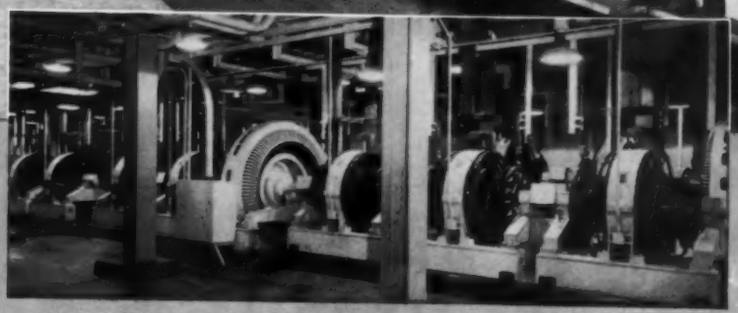
■ Since 1909, The Electric Products Company has led in the designing and manufacturing of direct-current motor-generators. For instance, in 1912, E.P. produced the first fully-automatic motor-generator battery charger for the rapidly-growing Electric Truck Industry. *Now, U. S. Steel has installed 49 circuits of E. P. battery charging equipment at the Fairless Works for servicing all of the batteries of their electric truck fleet.*

When the Steel Industry went to electrolytic tin-plating years ago, it was a natural step to take advantage of E.P.'s specialized experience to design and make a d-c motor-generator that would more than meet the exacting requirements of steel-mill service. *Today, the Fairless Works has installed 110,200 amperes of E. P. motor-generator capacity for all of their electrolytic tin-plating requirements.*

In 1923, the need arose for a motor-generator that could not be over-loaded. The answer was the E. P. Diverter-Pole design. Widely used throughout the Central Station Industry for control-bus duty, U. S. Steel uses them for servicing the switchgear batteries at their Fairless Works.

Throughout all branches of Industry, E. P. Motor-Generators of all types have been assuring unvarying dependability for years of trouble-free service.

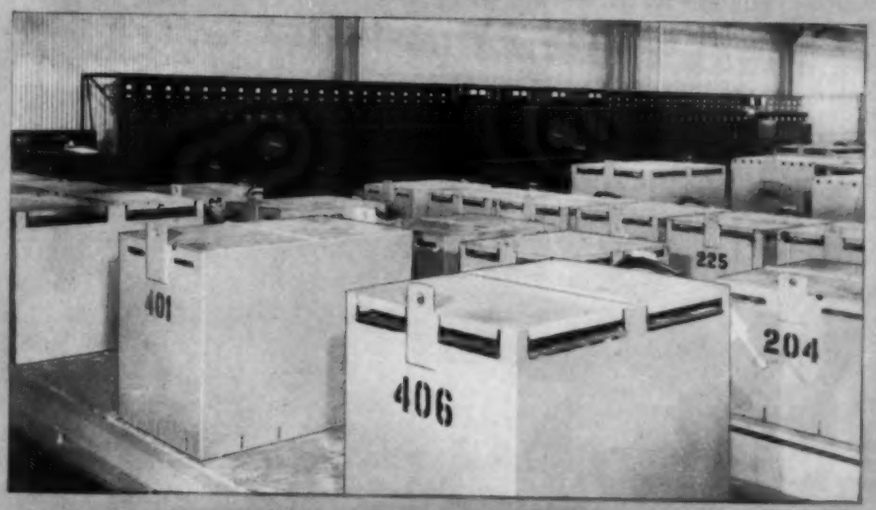




■ The generators shown here supply d-c amperes for plating, tin recovery and chemical treating.

■ In the background are the control panels for the five, 75-kw, 1585-ampere, 47.3-volt motor-generators (shown to the right) that supply direct current for 46 battery-charging circuits.

■ The arrow points to the smallest E. P. battery charger. It services a six-cell, 250-ampere-hour, lead-acid battery.



EP

THE ELECTRIC PRODUCTS COMPANY

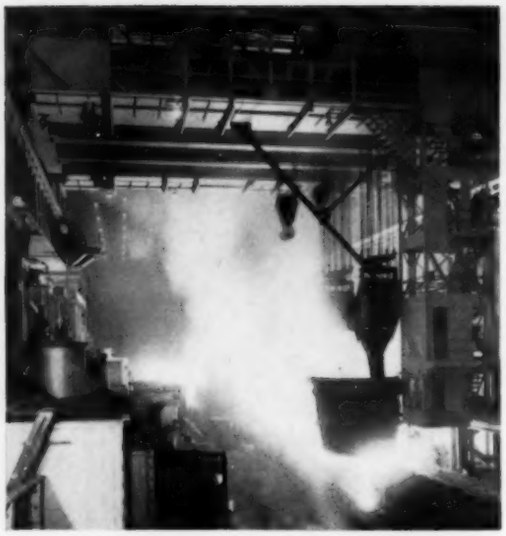
1725 CLARKSTONE ROAD CLEVELAND 12, OHIO

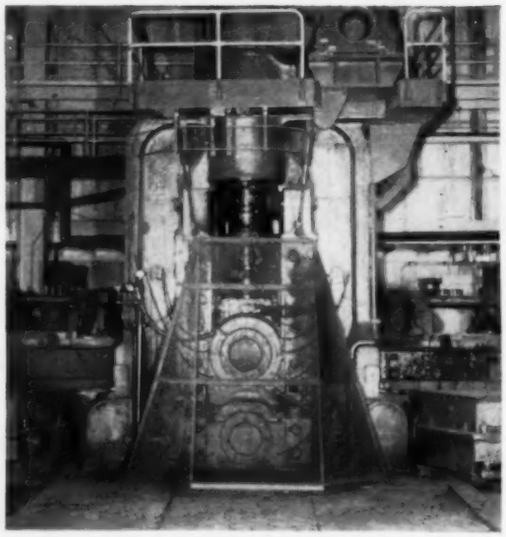
Trabon

LUBRICATION SYSTEMS

IN OPERATION AT FAIRLESS WORKS

this has a BEARING on production





About 20,000 bearings on a wide range of equipment at U. S. Steel's new Fairless Works are being lubricated around the clock by TRABON.

TRABON lubrication systems, automatic and manual, on such equipment as ore bridges, scale breakers, blast furnaces, cranes, hot strip and blooming mills, assure the right amount of oil or grease where and when it's needed.

This installation is typical of the versatility of TRABON *positive* lubrication.

PHOTOS COURTESY U. S. STEEL CORPORATION

Trabon

ENGINEERING CORPORATION

1814 E. 40th STREET • CLEVELAND 3, OHIO

Oil and Grease Systems

PHOTOS COURTESY U. S. STEEL CORPORATION

The installation of Trabon *positive* lubrication systems, both automatic and manual, on equipment at U. S. Steel's new Fairless Works was efficiently and economically engineered and supervised by the Ritter Engineering Company. This tremendous installation assures the right amount of lubricant to about 20,000 bearings on a wide range of equipment, and at the right time.

Ritter's many years of experience and staff of competent engineering personnel will enable it to do a similar job for *you*.

Trabon

"Centralized" OIL AND GREASE SYSTEMS

"Meterflo" OIL CIRCULATING SYSTEMS

CONVENTIONAL CIRCULATING OIL SYSTEMS

Ritter ENGINEERING COMPANY

1515 WEST LIBERTY AVE. • PITTSBURGH 26, PA.

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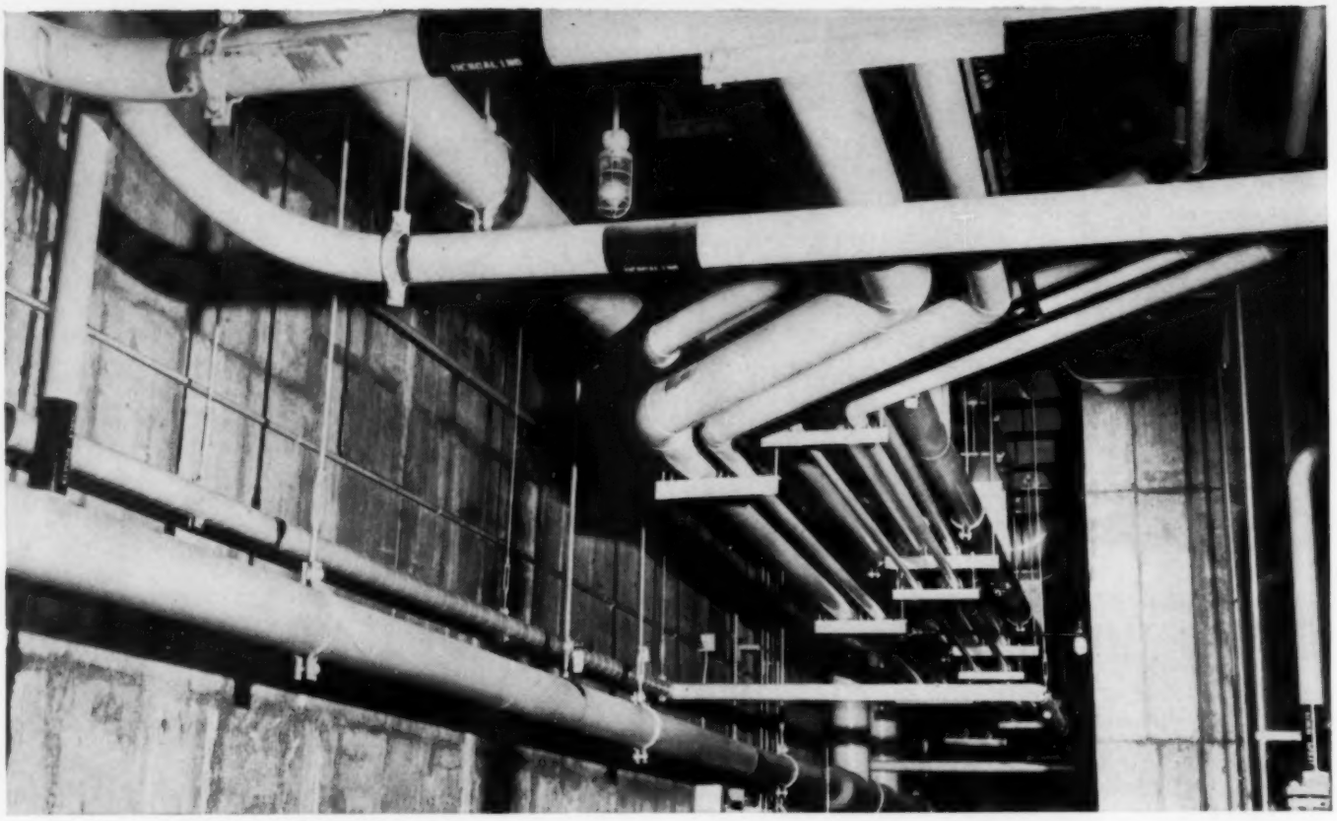
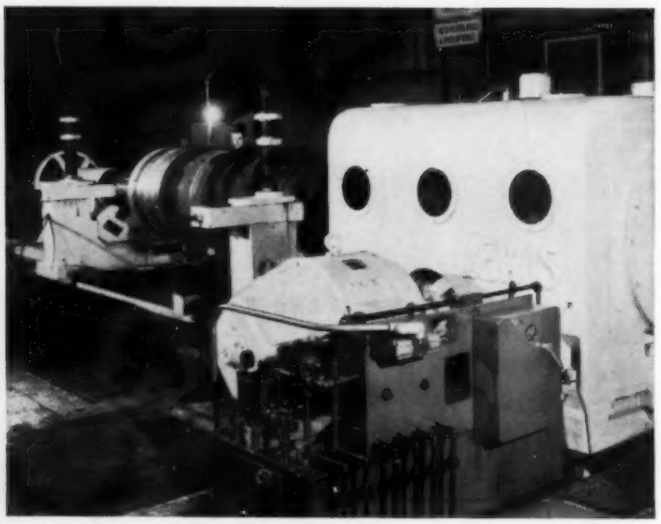


This piping in the hot strip mill tunnel is part of the complete piping systems for the hot strip mill and the slabbing mill, which were fabricated and erected by Blaw-Knox.

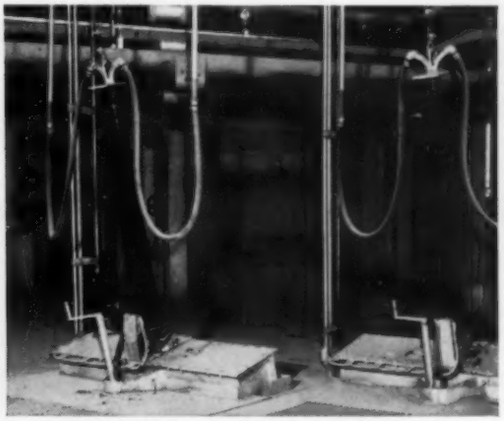
BLAW-KNOX Products in the Fairless Works of U. S. Steel are typical of the service that Blaw-Knox has been rendering the steel industry for many years. These are typical installations.



Left—three Lewis 18″ x 96″ roll lathes; and *right*—Lewis 60″ x 240″ hydraulic roll lathe. Among the rolls turned on these machines are our Pittsburgh and Lewis rolls used in the hot strip mill, slabbing mill, billet mill, bar mill, blooming mill, cold reduction mill and skelp mill.

Making up an open hearth furnace with a Blaw-Knox dolomite machine. Blaw-Knox water-cooled doors, frames and door hoists are used in the nine open hearth furnaces.

Grating installation in the gallery of the strip mill is typical of the thousands of feet of Blaw-Knox Electroforged® steel grating throughout the Fairless Works.



Blaw-Knox stack dampers and waste heat boiler dampers used in operating open hearth furnaces.

Handling slag in the open hearth pit, this 4 cu. yd., double lever arm bucket is just one of a number of Blaw-Knox buckets used for various purposes throughout the works.

Other Blaw-Knox products used in the Fairless Works, but not shown here, are our reversing valves for changing direction of the fuel flow to open hearth furnaces —and our heat resistant alloy castings for the continuous tin plate annealing lines, the coil annealing furnaces in the sheet mill, and the slab heating furnaces.

For further information about Blaw-Knox products and services for the steel industry, write to

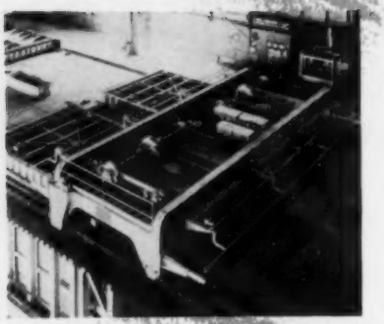
BLAW-KNOX

BLAW-KNOX COMPANY

Farmers Bank Building • Pittsburgh 22, Pennsylvania

Blaw-Knox Products for Metal Producing Industry: rolling mills and auxiliary machinery • rolls for steel and non-ferrous mills • water cooled equipment for high temperature furnaces • water cooled reversing valves • dolomite machines • autopours • clamshell buckets • heavy steel castings • heat and corrosion resisting alloy castings • prefabricated piping systems • open steel grating • sprinkler systems for fire protection

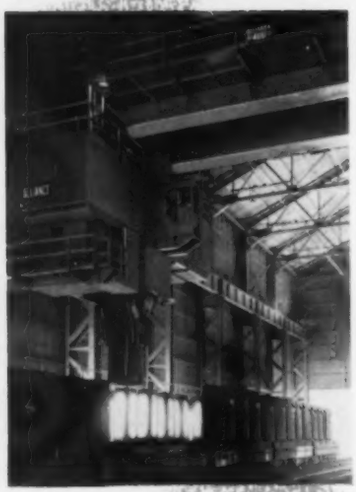
Re-ladling from submarine cars to ladle of hot metal crane safely under EC&M Control



Soaking Pit Cover Cranes with EC&M Control — outrigger arms remove power . . . set brake

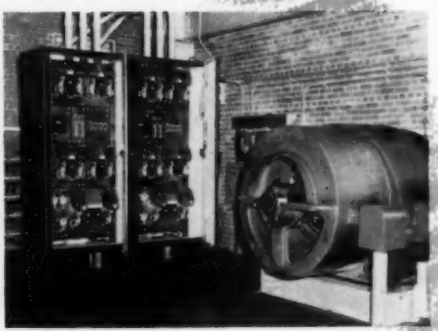
Charging machines with EC&M Disconnect Switch and TIME-CURRENT Controllers

CONTROL STARTS



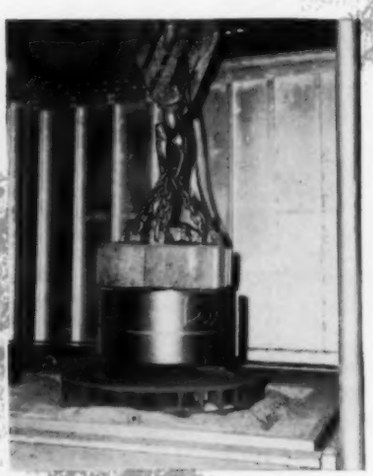
Stripping ingots with 400-Ton Stripper crane under EC&M Control

Pair of EC&M Type BR Magnets mounted on spreader-beam speed steel handling



Two EC&M 600 HP Controllers for secondary of Hammermill Coal Crusher motors

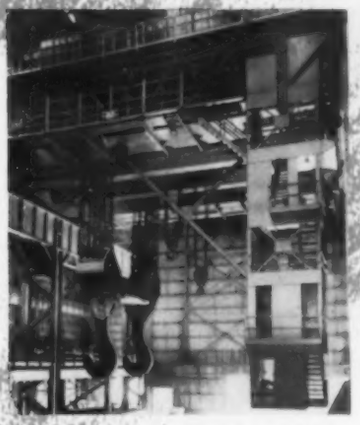
Larry car, coke pusher and door machine are efficiently operated by EC&M Control



CSM Coil Magnets don't overhang load — easy to guide through narrow aisle

Open hearth stockyard cranes with EC&M Controllers on crane footwalk

World's longest single-flight coke conveyor — EC&M NEO-TIME-CURRENT Controlled



World's largest ladle crane — 450-ton capacity — EC&M Controlled

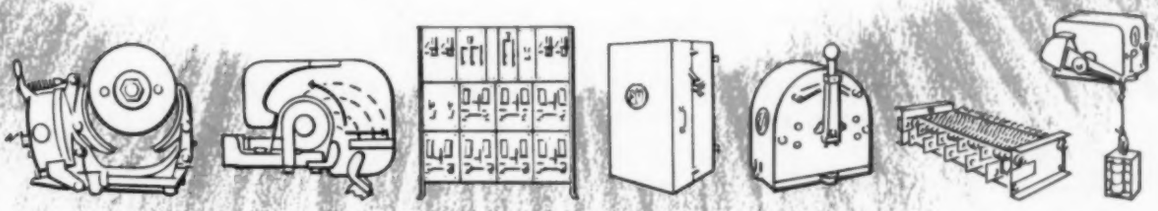
WITH

EC&M Control Excels in Performance . . . assures lowest upkeep

Performance proves EC&M control apparatus and control engineering give the greatest service at lowest upkeep.

Look at the proof of acceptance . . . the world's largest ladle crane . . . the world's longest single-flight conveyor belt . . . both EC&M controlled.

The BIG jobs are tough, but vital. Operation must be safe, dependable and economical. You'll find, as others have, that EC&M control is simplest . . . and has maximum safety advantages.



WB Brakes for A-c and D-c motors | LINE-ARC Contactors | Magnetic Crane Controllers | Disconnect Switch | Short-throw Cam Masters | TAB-WELD Resistors | Youngstown Limit Stop

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The line of EC&M CRANE CONTROL EQUIPMENT is complete

THE ELECTRIC CONTROLLER & MANUFACTURING COMPANY

2698 East 79th Street, Cleveland 4, Ohio

Another Bedford Mill Type Crane at Timken Roller Bearing Company

The Timken Roller Bearing Company has just installed a new 30-ton Bedford crane over the stripper building in their mill at Canton, Ohio. This is the second Bedford crane to be installed by the Timken Roller Bearing Company at Canton since July, 1952. The new crane has a 61′2″ span with 32′5″ lift. Built to AISE specifications, it has air-conditioned cab, worm drive gear on the hoist, and welded girders.

Proof of the superiority of Bedford cranes is found in the high percentage of repeat orders from important owners through the years.

Available in all types and sizes . . . from 5 tons to 350 tons, and up, for all kinds of indoor and outdoor services . . . each Bedford crane is individually engineered and precision built for its specific application.

Built to the most modern standards and backed by more than 52 years of specialized crane building and *utilization experience* . . . Bedford cranes have won fame the world over for advanced design—and for safe, smooth, more dependable performance.

You are invited to consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)

STEEL MILL CRANES BEDFORD

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

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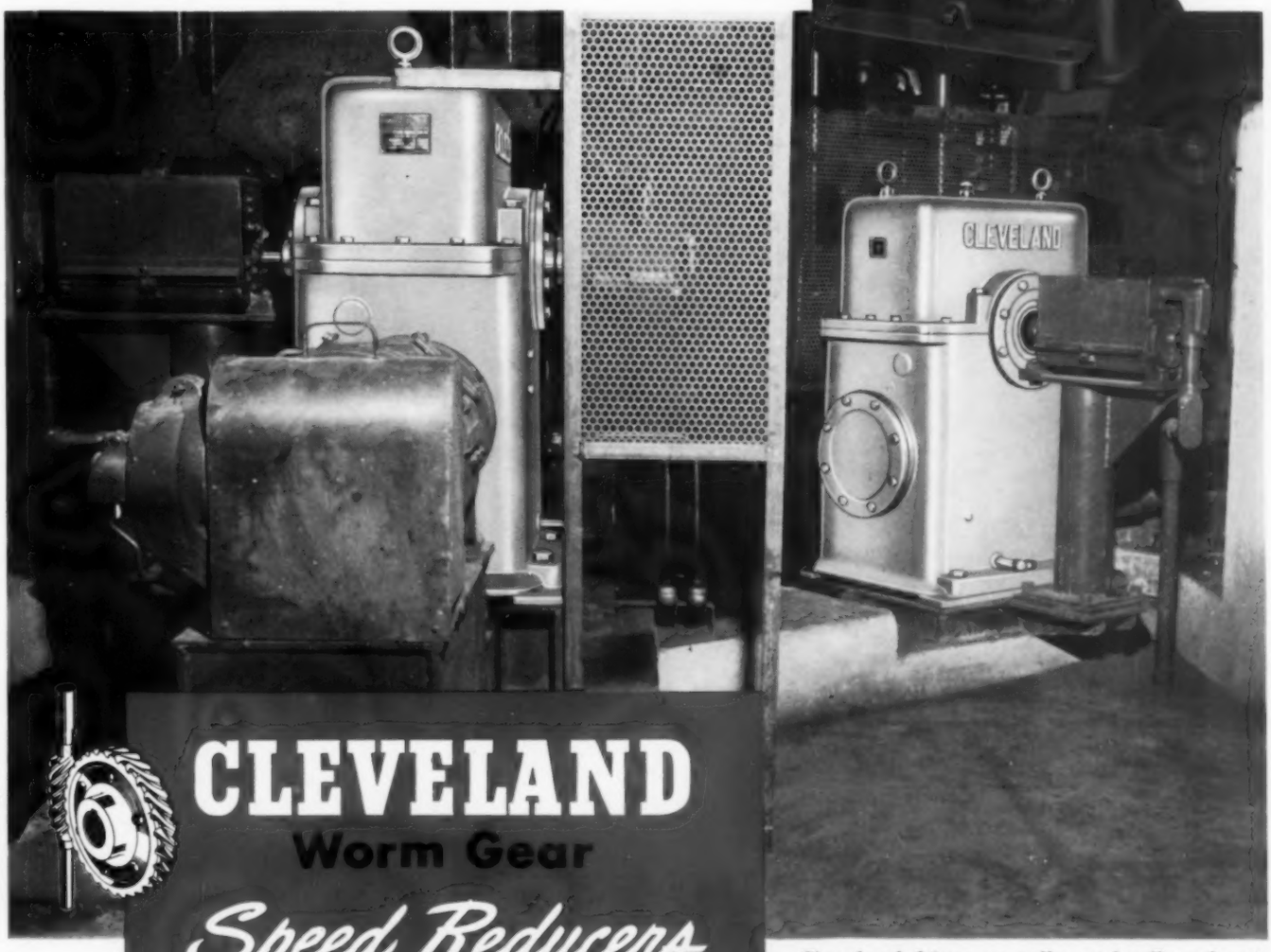
Clevelands

SERVE NATIONAL TUBE AT FAIRLESS WORKS

MORE than a hundred Cleveland Worm Gear drives are in service at the Fairless Works. In the National Tube Division, for example, Cleveland gearing and speed reducers drive such diverse equipment as cranes, conveyors, coilers, lathes, draw benches and pipe washing machine.

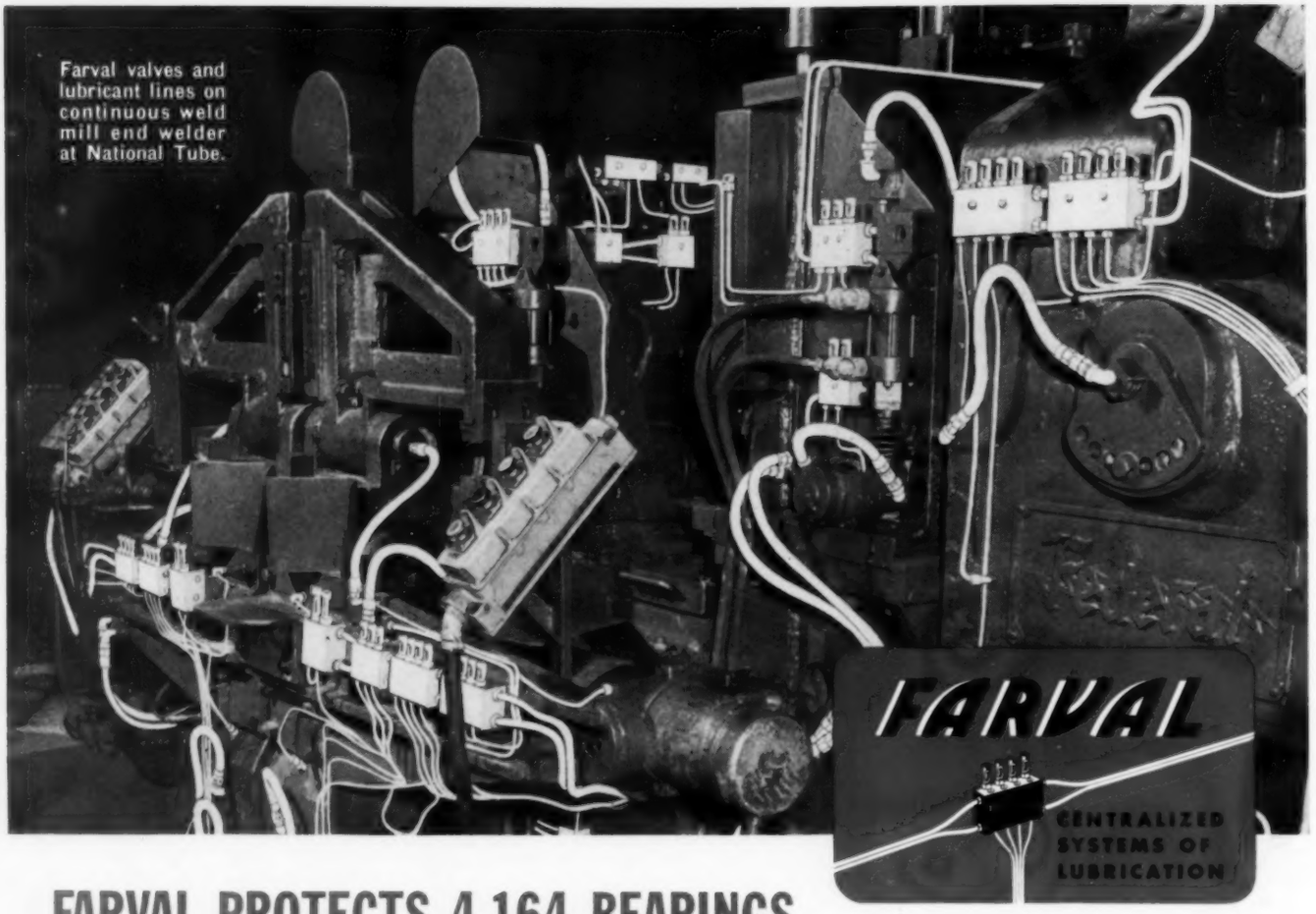
As at other plants of National Tube, and throughout the steel industry generally, Cleveland Worm Gear Speed Reducers serve dependably. Steel men have known and used Clevelands for more than forty years. The Cleveland Worm and Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.



CLEVELAND
Worm Gear
Speed Reducers

Cleveland drives on coiler and coil push-out arms—skelp mill, National Tube Division.



Farval valves and lubricant lines on continuous weld mill end welder at National Tube.

FARVAL PROTECTS 4,164 BEARINGS

at National Tube's Fairless Works

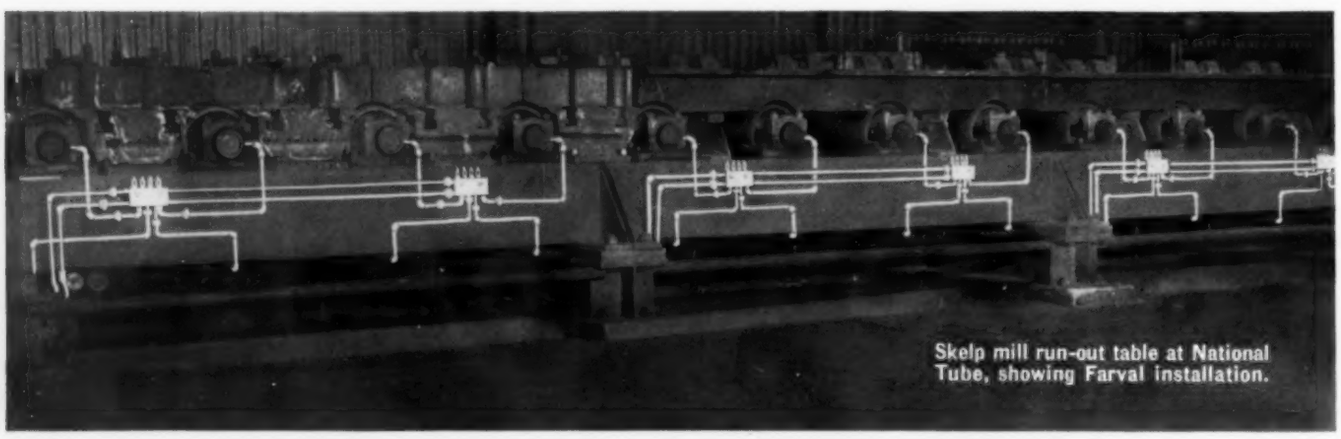
A TOTAL of 74 Farval heavy-duty automatic, manual Dualine and Multival systems of lubrication have been installed on equipment in the National Tube Division, with nearly a hundred systems on other equipment at the Fairless Works.

Here as in other plants of the United States Steel Corporation Farval Centralized Lubrication provides dependable protection for vital bearings on steel and tube-making mills and machines, saving labor, lubricant and available production time. The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing • In Canada: Peacock Brothers Limited.

SOME OF THE FAIRLESS WORKS EQUIPMENT SERVED BY FARVAL SYSTEMS

Butt Weld Tube Mills, Nos. 1 & 2 • 48-in. 5-Stand Tandem Cold Mill • 80-in. Single Stand Sheet Temper Mill • 80-in. 4-Stand Tandem Cold Mill • 2-Stand Tin Temper Mill • 10-Stand 19-in. Skelp Mill • Cranes • Run-out Tables • Trimmers • Levelers • Annealing Furnaces • Shears • Tubing Conveyors • Annealing Lines • Coke Equipment



Skelp mill run-out table at National Tube, showing Farval installation.

More Than Technology....

By MALCOLM W. REED

Executive Vice President — Engineering and Raw Materials

United States Steel Corp.

Pittsburgh, Pa.

....address delivered at AISE Spring Conference dinner, Philadelphia, Pa., May 4, 1954....

▲BASICALLY, the responsibility of iron and steel engineers, as of all others who have qualified themselves for the profession of engineering, never changes. It is to work in a public-serving way, always at the peak of professional standards of competence and ethics. Being mortal, we sometimes slip down a little from that peak. But if we slip very far or very often, it becomes idle to talk about corollary and current responsibilities, as they take form in the changing currents of political and economic conditions.

Engineers engaged in private enterprise, as we are, have another basic responsibility. I mean the obligation to do all in our power to keep the American economy strong. This responsibility, too, is unchanging. At least, any change in it should be only one of emphasis. Once in a while, the emphasis has to be on defense against forces shoving us backward; ideally, the emphasis should always be on constructive advance.

We now must fulfill that responsibility, to a greater degree than ever before. We must do it by unfailingly taking a lively and imaginative part—not a passive and pedestrian part—in helping to cut the cost of things the people need; in helping to develop new products and new processes that contribute to the forward momentum of the American economy.

Engineering has, in the past, fulfilled that responsibility in no trifling way. But I think the worst folly the profession could commit would be to rest content with past laurels. The priceless, yet intangible, reward of satisfaction in past jobs well done should only be a stimulus to the engineer's unending quest for higher productivity, which not only enriches the economy, but also results in the up-grading of human values.

It would do us no harm, I think, to reflect soberly on what engineering's achievements in the way of technological innovations and advancements have meant in terms of human values.

These innovations and advancements, in which you have had such a strong and capable hand in our industry, have done more than elevate the American people's standard of material well-being. They have done more than enable the American people, as consumers, to buy more and more that serves their comfort, convenience and safety.

The magnificent achievements that engineering has helped to evolve from the wheel and from ancient, immutable physical laws, have removed inhuman drudgery that was once so prevalent in human toil, and which exacted a frightful toll of body and spirit.

Yes, engineering has made its contribution to the elevation of the dignity of labor, and, therefore, to the elevation of the human spirit. It has enabled industry to afford increasingly better tools, increasingly better working conditions, and increasingly more jobs giving freer play to men's optimum abilities.

It would be stretching truth to a violation of the Law

of Elasticity to claim, in the name of engineering, predominant credit for the upgrading of human dignity that after all, truly, has been brought about by the industrial evolution that has been both possible and natural under our system of profit-motivated private enterprise.

The lion's share of the credit must go to the system itself. More admirably than any other yet devised by the mind of man, that system has unleashed and given skillful, constructive direction to something I consider to be, next to basic religion, the greatest motivating force for human progress. That is hope of profit. Lest I seem crassly materialistic, let me swiftly say that I do not, by any means, regard profit or personal gain in monetary terms alone. I mean also the reward that comes from sense of individual accomplishment and team accomplishment; from using one's talents, whatever they are, to the best effect; from the opportunity to feel that what you are doing is helpful to others, valuable to society.

The progress we have made under our system is a remarkable tribute to the technical-mindedness of our whole population, and especially to American labor. American labor has shown a great and constructive capacity to understand and use technical innovations. More than that, labor has suggested many technical advancements which engineers have been able to develop into profitable, practical use. I know how true this is in U. S. Steel. I know that it is true throughout American industry.

Having dispensed a measure of credit where I believe sincerely credit is due, let me return to the matter of engineering responsibilities.

Engineers have the obligation to do more than keep their technical skills from becoming rusty and their ingenuity from becoming dull. They must not neglect their economic and political perceptiveness. As engineers, we must comprehend how changing economic and political circumstances affect what we do. We must keep fully awake to how the policies and practices of private enterprise, and our contributions to them, affect the economy and change the political climate. For example, the way the political winds are blowing may determine in considerable degree the scope of the engineer's undertakings in the field of public works, in relation to the scope of his functioning in private enterprise. In other words, we need a little economic and political savvy to go along with our technology.

It seems to me that engineering in all its branches often becomes so immersed in technology, so engrossed in specialization, that the profession seldom speaks up as a whole and registers its opinion about anything except technology.

Our profession possesses some of the best brains in the nation. It is often at a vantage point to discern blunders and overlooked opportunities in both private enterprise and public affairs. And we have a ready-made bridge within the profession, across which to conduct an exchange of the problems and viewpoints of private enterprise and of government. The most authoritative data I could find indicates that one out of every five or six engineers in the United States is in the employ of government—federal, state, and local. I doubt that any other major profession has any higher percentage of its practitioners on the administrative side of government. Proportionately, there are probably as many engineers in government as there are lawyers, if you exclude the legislative bodies where the learned counselors seem to abound. Maybe we could use this intra-professional bridge we possess for communication of economic and political knowledge.

Yes, I think engineering has the potentiality to speak up, with a firm and authoritative professional voice. It should become vocal about conditions that adversely affect the growth of our economy, wherever and whenever those conditions meet the engineering eye. It should become militantly vocal about conditions which prevent our system of competitive private enterprise from working the way it should work.

The successful working of our enterprise system is dependent in no small degree on public understanding and acceptance of an undeniable truth. It is: that not one inch of human progress has been made, or ever will be, without at least a little inconvenience to someone. Engineers are concerned primarily with doing rather than talking, and I believe will never permit more glibness to become a mark of the profession. But I believe we can and should be more articulate than we have in the past, in helping to further public understanding of this; that progress for the many almost always involves inconvenience for a few.

In a little book with the ambitious title of "Economics in One Lesson," Henry Hazlitt points out that if the desirable and Utopian end of abolishing all vice and crime were reached, more than burglars, bandits and bootleggers would be out of work. Criminal prosecutors, reformers, judges, jailers and policemen would be subject to widespread technological unemployment. But would that be any reason for calling off man's eternal fight against the vicious and the evil? Technological unemployment resulting from a world rid of crime would, of course, be more than made up by increased employment resulting from the flow into legitimate channels of industry and commerce, of effort now eaten up by crime's wanton waste of life and property.

That was not intended as a moral homily. It was intended only to illustrate this point: When engineers bring about achievements that affect the pattern of employment, they should be able to show, in words the people will understand, that what they have done will clearly benefit more persons than it will hurt.

Another responsibility of engineers is to maintain open-mindedness and flexible-mindedness. We should not accept, for instance, the idea that because we make steel by going through a gyration of processes from coke oven to blast furnace to open hearth, we will always have to do that. It is true that the blast furnace is, for its purpose, one of the most efficient devices man ever built. It is true that we do not yet know enough to change fundamentally for the better some of the mills built thirty or forty years ago. But these are no reasons to stop trying to find "the better way" that will permit more and more people to afford more and more things of steel. We must attack our problems in the boldly affirmative way that is illustrated by the manner in which engineering, and allied sciences, have attacked

the problem of obtaining efficient, economic usefulness from low-grade ores.

Certainly by the employment of open-mindedness and flexible-mindedness, we can find better ways of material-handling in the steel industry. To say that we do need those better ways, may rate as the understatement of the evening. And with steadily higher costs of steelmaking facilities, we certainly have to meet the challenge of keeping the over-all cost of steel at the point where it can continue to be fully competitive with other products vying for the same market we are. We have to meet that challenge either by bringing about a reduction in the cost of steelmaking facilities, or by making those facilities themselves so efficient that their cost will not be a factor precarious to our product in the competitive market. In other words, we have always and inescapably before us the challenge of learning how to design facilities to produce steel at a lower cost per ton.

Engineers must not, however, keep their noses so close to the technological grindstone that they convey to the public the idea that engineers can see things in only "technical dimensions."

We must demonstrate clearly that we see things in more than height and breadth; in more than terms of materials and function. We must convincingly show that engineers see things in the third dimension; that we have depth perception enabling us to use our knowledge and techniques for maximum social and economic usefulness. The engineer's thinking must not become so strait-jacketed that he is unable to see things whole. Engineering must not become so preoccupied with designing and building a bridge of great strength and beauty that it falls short of achieving good, well-rounded engineering. That is, to paraphrase a classic definition a little bit, engineering capable of deciding whether the bridge should be built in the first place; and if so, when and where.

Engineers cannot, of course, dodge or ignore the responsibility to see that the education of oncoming members of our profession keeps abreast of the times. I think we owe our support to the present system of engineering education called the binary curriculum. That system, as you know, requires a young person to spend three years in a liberal arts college obtaining a foundation in humanities and social studies; then two years in an engineering college. That kind of academic preparation for an engineer appeals to me as commendable in most respects. If it has any deficiency, it may well be a lack of sufficient emphasis on economics. If such a deficiency has to be made up at some sacrifice of technical studies, I would say well and good. I am inclined to agree with those who say that the only thing wrong with an engineering education is that it sometimes teaches too much engineering.

One of my associates recalls a professor he had who came on to the campus from fifteen years in the field. That professor used to hold up a textbook before a new class and say: "I can't teach you all that's in this book, but I can teach you all that you'll ever need to know." That was his way of saying that his function in education was much more than just a referee between the book and the student.

Perhaps we need a lot of that kind of attitude on the technical side of engineering education.

It is the engineer's responsibility to encourage the entrance into the engineering profession of the very cream of the crop of America's young manhood. We must offer that encouragement not only verbally, but by the example of irreproachable professional conduct and by the evidences of the engineer's contribution to a better society.

We do not want to attract to our ranks a big, or even a little complement of young people who *think* they want to be engineers just because they think they will find security. For a number of years you and I have been more than a little disturbed by firsthand reports from persons who interview engineering college seniors for employment and training in several branches of American industry. It seems that as many as half of the young men they talk to ask, no later than the third question, "How big a pension will I get when I retire?"

We want in the engineering profession young men who regard security not as the paramount goal, but as a byproduct that will surely be created by industry, by competence, by thinking big and thoroughly and by acting courageously. We want young people who will be engineers with both head and heart.

We want young people who will be able to give the right answer to the tough, recurring question that confronts engineers time and again. It is a question to which no amount of professional competence alone can supply the answer. The question is:

Will what I am doing, the undertaking I have envisioned, or the project on which I am embarked, help to make the American economy stronger?

In my long experience you who serve the iron and steel industry have seldom flunked that test. I hope you will always pass it with honor and praise and that your answers to the test will never reflect an inability to see the crowd because of the people, but will always reflect an ability to look at the crowd and see the people.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill", published by the Association of Iron and Steel Engineers. If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

By GLENN O. CARTER, Partner, Percival R. Moses and Associates, New York, N. Y.

USE OF OXYGEN IN STEEL MILLS

. . . . the decreasing cost of oxygen in large quantities has led to many new metallurgical uses . . . .

▲ THE use of oxygen is not new, as its value was known all through the nineteenth century. However, the welding and cutting processes for steel were not developed until acetylene became available at the start of this century. Oxygen was made from chemicals and in a few places by a process using recurring absorption from air by barium oxide, thus giving a recovery of oxygen of approximately 95 per cent purity.

In relation to oxygen usage, the year 1907 was truly significant for the steel industry; at that time the first air separation plant was begun in the United States in Buffalo. This plant was capable of producing oxygen of 97 per cent purity. Of equal importance at that time was the promotion of the use of oxygen, calcium carbide and acetylene under the auspices of strong financial interests.

COST AND PRODUCTION DATA

What has occurred since is statistically interesting and points to even greater production than the two billion cubic feet per month reached in 1953. Figures 1 and 2 show:

1. What has been the price structure in the important steel centers from 1907 to date.
2. Oxygen production over this period as taken from statistics for 1919-1951, as published in *Welding Engineer*, with the author's data approximating usage from 1907 to 1918 and for this current year.

It should be noted that purity of product has gone up in fractional degrees until it has reached the present 99.5 per cent.

Before discussing these figures, let us consider that the cost to the user has been brought down, first in distribution charges by extensive building of oxygen producing units located to serve every important industrial center, and secondly by reduction in price at the plants through competition within the industry through competing processes as well as between companies, using the then new but now the standard method which is air liquefaction and separation.

The curves of Figure 1 show the general prices at the production plants for large users and small ones, together with an estimation of delivery and user costs, to arrive at the actual costs at the consuming devices.

The curves of Figure 2 for average monthly oxygen

Figure 1 — Oxygen costs in steel centers have decreased continuously from the time of the introduction of air separation in 1907.

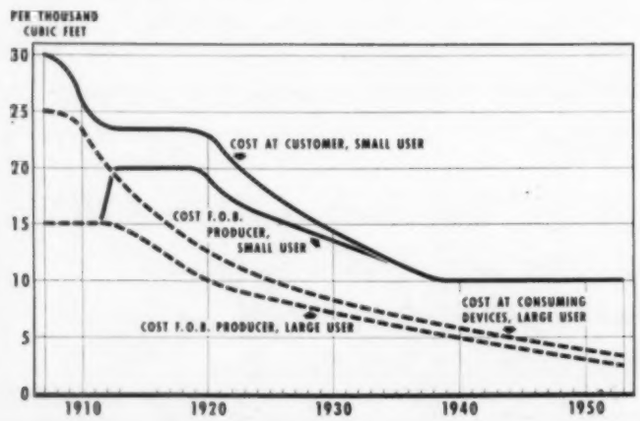
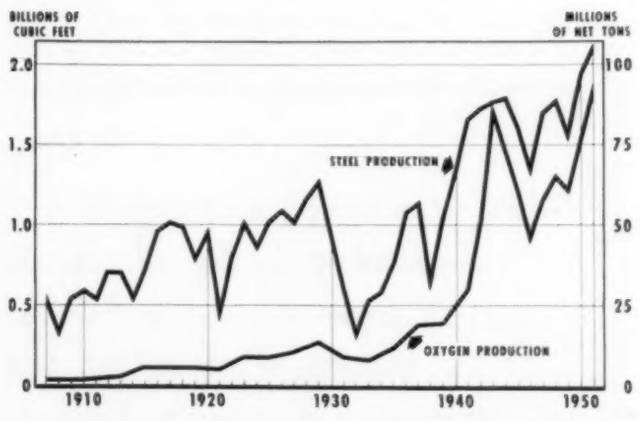


Figure 2 — Oxygen usage has increased at a rate which corresponds closely to increase in steel production as shown on this chart.



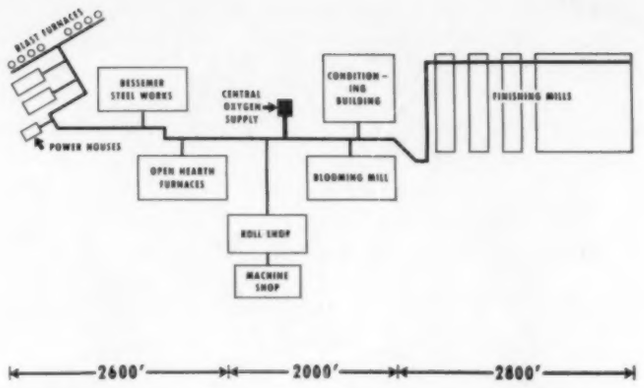


Figure 3 — A typical oxygen distribution system in the steel plant covers a great deal of territory.

production are supplemented by annual tonnage of steel and iron production. The data on oxygen generally reported is for "high purity," but a short curve is added to cover production in recent years of "tonnage" oxygen, which is rated as being 95 per cent pure or less. These data are included so we can all watch the developments that will follow reduced costs of production of oxygen at the works and greater availability.

Cost of distribution was high when shipment by railroad freight or express was required from the few central plants, and local trucking by teams of horses was standard. Cylinders were 35 per cent heavier before 1914 than afterwards, which made a difference in distribution costs.

At present practically all oxygen is supplied at a delivered price. The effect has been to make the cost of oxygen at the blowpipe lower for small users today than for large users at the end of World War I.

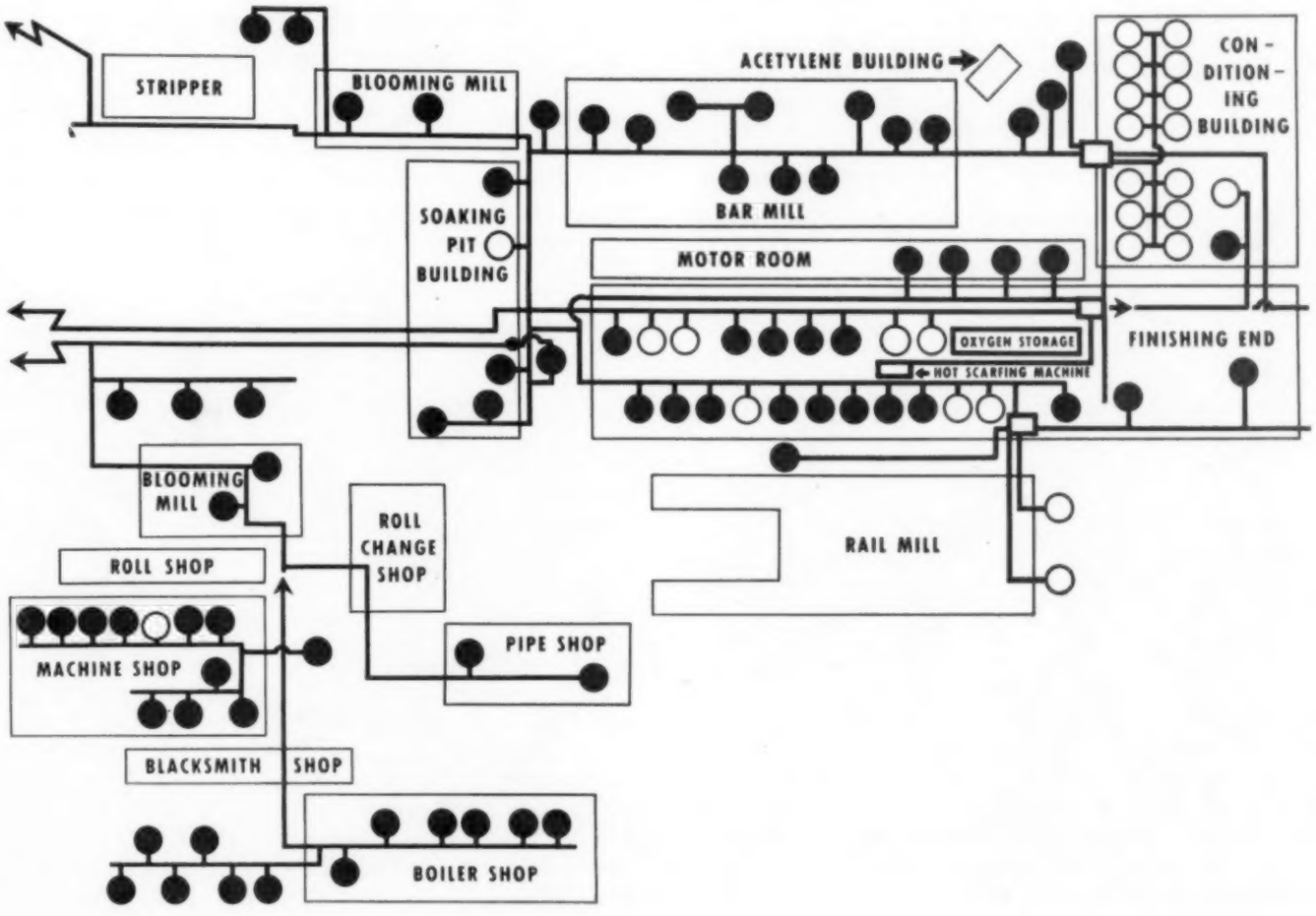
Further reduction in costs have been based upon distribution of oxygen in liquid form at temperatures only a little above minus 300 F. This and other methods of bulk supply necessitate the use of pipe lines from distribution centers of a steel works to the major points of utilization.

CONSIDERATION OF UTILIZATION

In the period prior to 1917 there were a few successful production uses of the oxy-acetylene processes in welding metal drums, tanks to be enameled, automobile rear axle housings, repairing defective engine castings, etc. In cutting should be noted scrap metal preparation, the severance of armor plate, and forging and removal of risers from steel castings. But the major operations were the emergency ones of cutting of cobbles, dismantling machinery, modifying structures for repairs and welding of broken or eroded equipment.

The cost of oxygen at the blowpipe was then so high and of labor so low that savings in time seldom warranted use of welding and cutting in competitive production operations. The rising cost of labor and the decreasing

Figure 4 — Extensive manifolding is required for an oxygen distribution system in the steel plant.



cost of oxygen have changed the economics of operating shops until today the steel works have become dependent in production work upon oxygen with acetylene or other fuel gas. As a rule, no alternative methods are now provided, whereas oxy-acetylene cutting may often be adapted quickly to replace other methods of severance when breakdowns occur.

With increased use as warranted by these economic changes, and with dependence upon the gases for production, it was natural that the shipping containers, cylinders, be manifolded near the point of use and that pipe lines carry the oxygen and fuel gas to the working floor. This was also conducive to safety by keeping cylinders from positions where they could be hit. This was another form of saving in distribution costs.

These locally piped shops were readily tied together when bulk distribution of oxygen involved the piping from central points, and are now ready for connection to oxygen production units.

EXTENT OF OXYGEN PIPING IN A STEEL WORKS

Much could be said about details of design of oxygen lines and fittings, also about precautions in erection such as freedom from oil. But with this note no further mention will be made in this paper.

The piping of a steel works for oxygen is an extensive job as may be judged from Figure 3 which shows a main line of several thousand feet for a typical steel works. This will be at least six inches in diameter for an operating pressure of 125 to 150 psi gage with a maximum of 300 psi. The flow of oxygen may fluctuate a great deal, so the calculations should provide for actual maximum rate of delivery past any given point.

Service piping is then taken off for individual shops or activities, which often makes an intricate system. Figure 4 is used to portray piping within the central section of Figure 3. The consuming devices are cutting blowpipes, both hand and machine controlled, hand scarfing equipment, machine scarfing of hot billets or blooms, and other specialized intermittent uses.

Each apparatus must have adequately controlled flow so regulation by shops or at each piece of equipment is needed. In some cases storage with regulation is installed to stabilize the rate of flow.

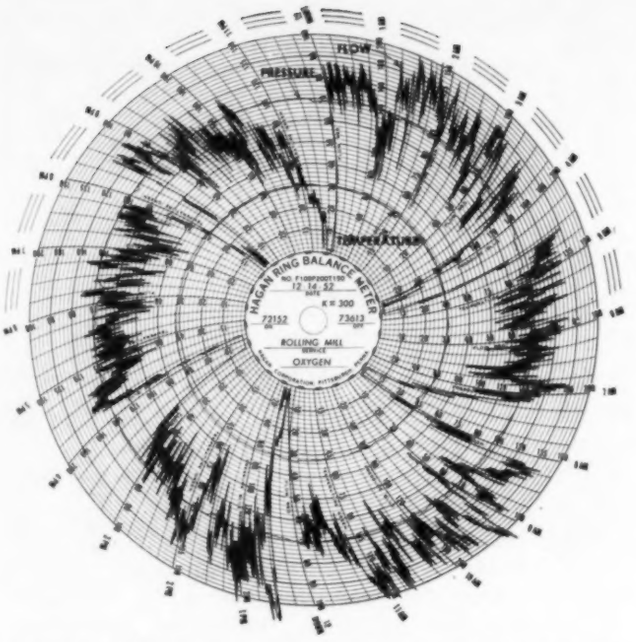


Figure 6 — Chart shows oxygen requirements for a rolling mill.

ALLOCATION OF OXYGEN USED — METERS AND CHARTS

Present U.S. practice is that where an oxygen line is installed the oxygen is paid for as measured at the

Figure 5 — Oxygen requirements for the blast furnace have high peak demands.

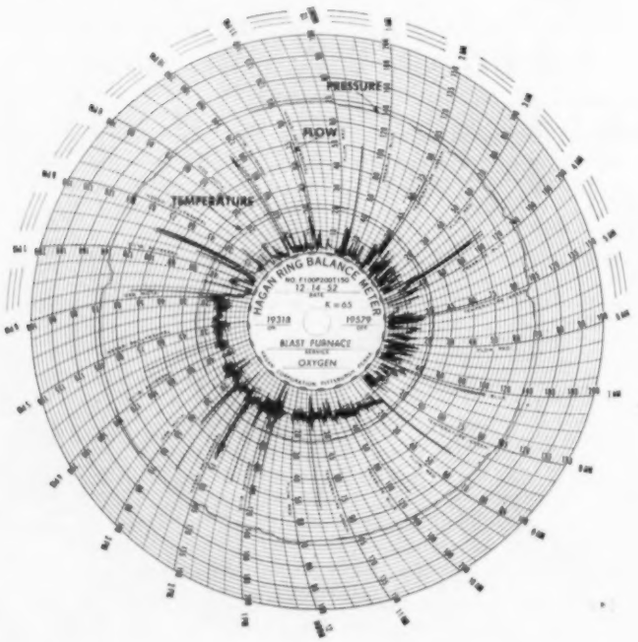
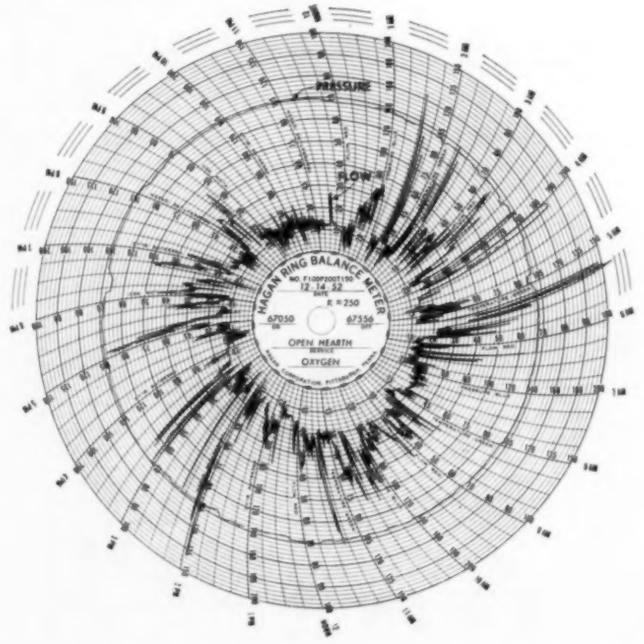


Figure 7 — Chart gives oxygen requirements in open hearth shop.



point of delivery. The allocation of costs within a works is comparable to cost accounting for electricity, steam, compressed air, fuel gases or annealing gases. These are all utilities.

Estimation of usage in the various shops has been one of the methods of allocation, prorating the total bill including the service charge of the works.

Metering, a much more exact means of apportionment, has been tried by use of special displacement meters for oxygen, but the wide fluctuations of consumption, as required at many places, calls for large meters or batteries of meters. First cost of equipment is high and so has been maintenance. A further problem is obtaining of actual usage data from minute to minute or hour to hour, which is needed in determining pipe line sizes, pressures, storage capacity, etc.

Orifice meters give satisfactory results but have characteristics that make comparison of charts from different shops difficult unless they are reduced to a quantitative rating. These meters do indicate the large fluctuations and record the amounts used. The charts carry much information as to the adequacy of supply, wastage, etc., and should be checked as carefully as are charts from electric meters.

CHARTS FOR ONE DAY OF OPERATION

Within a year the writer had an opportunity to study a system in which all the oxygen delivered to the works was metered to points of use. Three meters carried the total, although there were three additional meters beyond the master ones.

The three charts for one day are shown. See Figures 5, 6, and 7. Figure 5 is for blast furnaces and shows typical heavy but short demands for tap hole opening. Figure 6 is for a line to the rolling mill and structural mill with a supplementary line beyond the structural shop. Figure 7 is from the line to the open hearth shop with a metered extension to the maintenance shop.

Attention is called to the fact that each chart is based upon its own size of orifice so each has a different factor. Characteristics of the requirements of each line are well shown as is the curve for pressure. Some of the curves for other days pointed to delays in transferring liquid oxygen to the converters and other operational conditions.

The three master charts were developed on a horizontal scale to show actual rates of consumption, and they were then added together to give the chart for total rate of use and account for the twenty four hours involved. This shows what was needed to give adequate quantity on the lines at the central station. An interpretation not only shows the heavy demands at times, but the periods of almost complete shutdowns when charging turns and at midturn.

In contemplation of providing an oxygen production plant, this indicates daily totals which vary considerably, but also the provision for storage and reserve production. In estimates referred to, that oxygen can be supplied for less than a dollar per thousand, this has been provided for with an average use of a million feet per day.

The problems of heavy usage for short periods is one for consideration, but with the pressure storage system

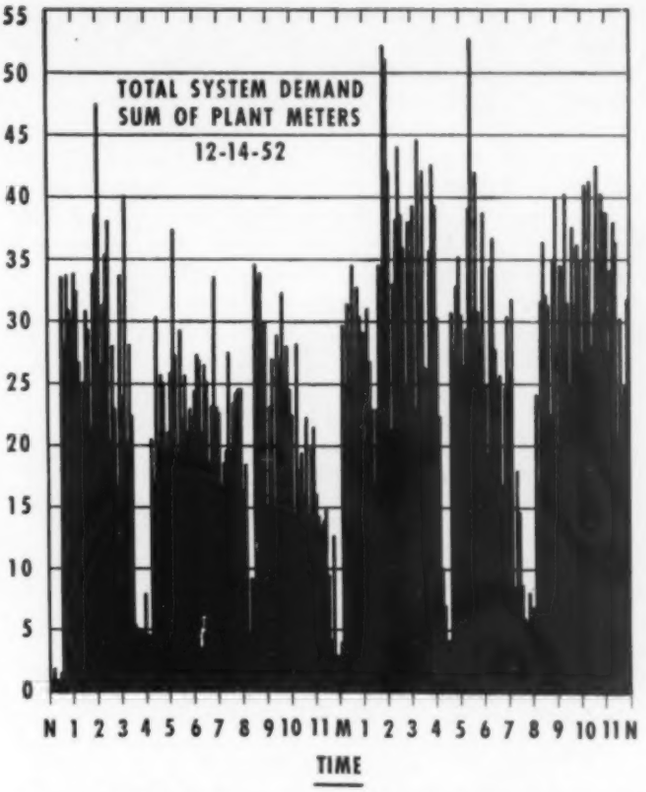


Figure 8 — Rate of flow of oxygen for steel plant system in thousands of cubic feet is given in this chart.

it is nothing like the uncushioned loads thrown on electrical systems by electric furnaces, large motors and other equipment.

STATUS OF PRESENT USES

There has been marked growth in the use of oxygen in those processes involving cutting of iron and steel. Few of the applications are new, so we must look to the favorable balance of present oxygen costs with labor costs for the marked increase in quantities used. The present oxygen bill of the U. S. at bulk prices exceeds $4,000,000 per month.

In scrap preparation where skulls were formerly drilled, often with oxygen, explosives were used to shatter them. Today large cutting units are mounted so as to traverse these large chunks of ladle size and cut across them, frequently making several passes so that further work is not required to get charging box sized pieces.

Shears are important for cutting structural scrap and plate steel, but the ease with which oxygen cutting may be done anywhere in the yard offsets the problem of crane service for taking steel to shears. Much metal is recovered now that would have been buried a generation ago.

Accurate cutting with oxygen to dimension is now regular practice in plate, structural and pipe shops. This has the advantage of keeping the scrap at home. It is a production step in making of weldments. Cutting of this nature at the shipyards followed by welding had much to do with the Nation's marvelous wartime record of ship construction both naval and commercial.

Shortly after World War I, the removal of surface

defects of steel slabs and blooms with oxy-acetylene apparatus was used in the Pittsburgh district and reported on by the author who devoted years to work in steel and industrial plants to the encouragement of known and new applications. It was learned that this had proven to be good practice during periods of labor shortage when it was difficult to employ men to operate the compressed air driven chipping hammers generally used for gouging out surface flaws. With return to normal labor availability, oxygen could not compete. Please note the cost structure at that time, then ten years later when the scarfing or gouging operation with oxygen was reintroduced. This time it was a sound practice which has grown through improvement in apparatus until mechanical gouging is rarely used.

In the early thirties, two Pittsburgh works engineers considered mechanization of hot scarfing as being feasible. At the time the writer and associates were studying the mechanical operation of single blowpipes so as to plane parts of slab surfaces. A few days later a simple demonstration was made of scarfing small hot billets, and an order was given for the first large works type unit which was in the district.

Basically the success of the process of complete surface removal depended on two things:

1. By taking off a thin layer to remove so much of the troublesome zone of the surface as to permit finishing of the steel without loss of heat and with no inspection.
2. Ability to do this economically.

History indicates that these conditions were met, and although hot scarfing machines are expensive, they have enabled users to make large savings over the previous practices. Both machines and hand scarfing are used in many works. The volume of oxygen going into scarfing has increased from year to year, and may continue to increase with lower costs for oxygen being conducive to obtaining almost complete surface cleaning.

A further development is powder scarfing of alloy slabs and blooms where the plain oxygen jet does not combine with the surface layer of the steel.

Use of oxygen in furnaces has been increasing over some years. This is definitely related to oxygen cost as tests were conducted in this district, in which the writer cooperated, as far back as the early twenties. Manifolded oxygen cylinders gave the supply which was used similarly to present methods with steam atomized tar burners using oxygen. Results were definitely good in saving of time of heat, but with cost of oxygen at that time the economics were against the use.

With present cost of one and a half dollars per thousand, the use of oxygen approaches an economic balance. In some cases where furnace charging apparatus and other conditions permit, oxygen is being used to get a high rate of steel production.

A second use of oxygen in furnaces is to decarburize the steel in the molten bath. This is of growing interest, both for open hearth and electric furnaces. Both furnace operations could utilize lower purity than that required for previously mentioned cutting uses.

FUTURE POSSIBILITIES

The future points to even greater use of oxygen, in all operations that are now accepted, with further reduction in oxygen costs. The metallurgical uses mentioned and certain blast furnace uses will take so much oxygen that the production curve will rise many more times. Even as it is, the author was tempted to plot this curve on logarithmic paper to keep it within bounds.

The steel industry is an outgrowth of the use of diluted oxygen in the form of air. Because this was the cheapest way of getting the oxygen, the presence of four times as much nitrogen was accepted. Use of air limits the temperature of combustion, the nitrogen acts as a space filler and is a cause of much heat loss. But the steel industry has from its beginning adapted itself to this and only recently has the reduction or exclusion of nitrogen in furnaces received much study.

However, thought both in Europe and in this country is being given to use of oxygen enriched air or medium to high purity oxygen up to the 99.5 per cent required for most uses. Economics will determine whether a steel works should have two oxygen systems of which one would be like that shown in Figures 3 and 4, and the low purity oxygen system or systems be attached to furnace shops only.

CHRONOLOGY OF MAJOR EVENTS IN OXYGEN PRODUCTION

1907 — First air separation plant, Buffalo, N. Y.; oxy-acetylene welding and cutting processes introduced.

1909 — Second air separation plant, East Chicago, Ill.; several electrolytic oxygen and hydrogen units.

1912 — Three more air separation units and installation of privately owned electrolytic and chemical production units.

1913 — Linde operating four plants — predecessor of Air Reduction built plant; International Oxygen Co.

1914 — Linde added several units; Superior Oxygen started with four plants.

1915 — Start of World War I; oxygen much in demand
1918 for munition work, cutting and maintenance; large increase in number of production units; Air Reduction absorbed Superior Oxygen Co. and added units.

1919 — Post-war development of uses; plant capacity exceeded demand.

1919 — Largest users in steel 350,000 cubic feet per
1921 month; in railroads same; not over 300 plants used over 10,000 cubic feet.

1922 — Predecessor of National Cylinder Gas intro-
1929 duced German Messer oxygen producing plants both for steel works and local marketing; all producing companies added oxygen plants.

1930 — Linde bought Heyland patents for liquid oxygen
1939 distribution and developed its service by railroad cars and tank trucks. Truck trailers developed for bulk oxygen delivery under pressure. Scarfing of steel became major use. Pipe lines built to distribute oxygen.

1940 — World War II caused increase in production
1950 facilities; shipbuilding became dependent upon oxygen cutting; steel industry also; shipbuilding almost ceased in 1946, but all other industries continued heavy use of oxygen; 1946 started promotion of tonnage oxygen for steel and chemical industries.

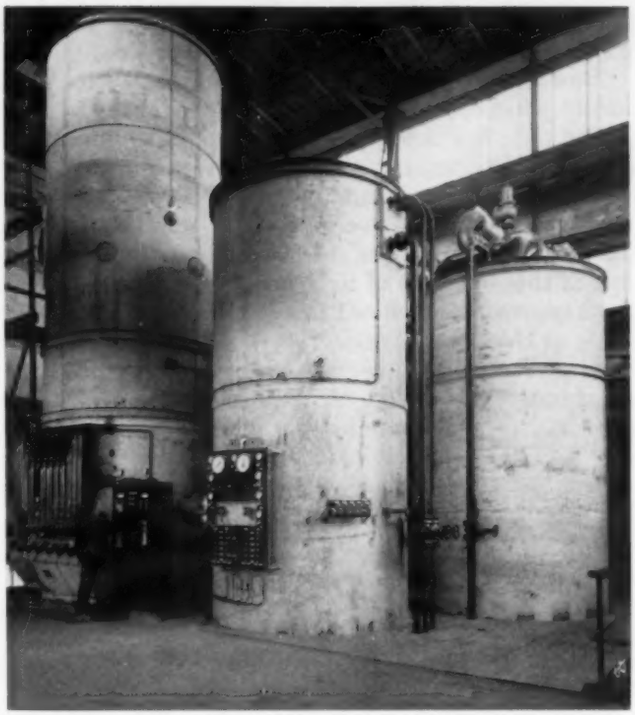


Figure 9 — Illustration shows large European production unit which produces 110 tons per day of 99.5 per cent pure product.

1950 — Construction of oxygen plants in steel works on lease basis; plans being made for steel company owned oxygen plants.

EUROPEAN PRACTICE

In the past month, the author visited several French, Belgian and German steel works. They included a works that has been operating a large low purity oxygen plant for 16 years, another that has had two years of oxygen supply from a producing company that pipes the supply into the works, one that had over a year's experience with 95 per cent product and an auxiliary high purity column, an identical system with two months' operation, two units under construction for making 99.5 per cent pure product and two commercial production plants.

The size of these units at the steel works varies from 227,500 cubic feet per hour of 73 per cent (166,000 cubic feet oxygen) to 87,500 cubic feet per hour of 99.5 per cent, which puts them into the category being considered in my paper as the next step in oxygen production in the United States.

The major use of oxygen in large volume is in the Thomas converters where quality of steel is improved and output increased. There were no scarfing machines in use, although one is provided for at Sollac (Selemange) in France. Otherwise, practices of oxygen use of 99.5 per cent quality are comparable with our practices. Experiments with the oxygen lance in open hearth and electric furnaces are going on, and there is interest in flame enrichment in open hearths particularly where tonnage oxygen is available.

It is not the writer's province to judge as to the exact cycles of oxygen used at the various works. But there is so much interest that a symposium on oxygen use in Europe was held in May, 1953 at Liege, Belgium, where a dozen or more fine papers were given.

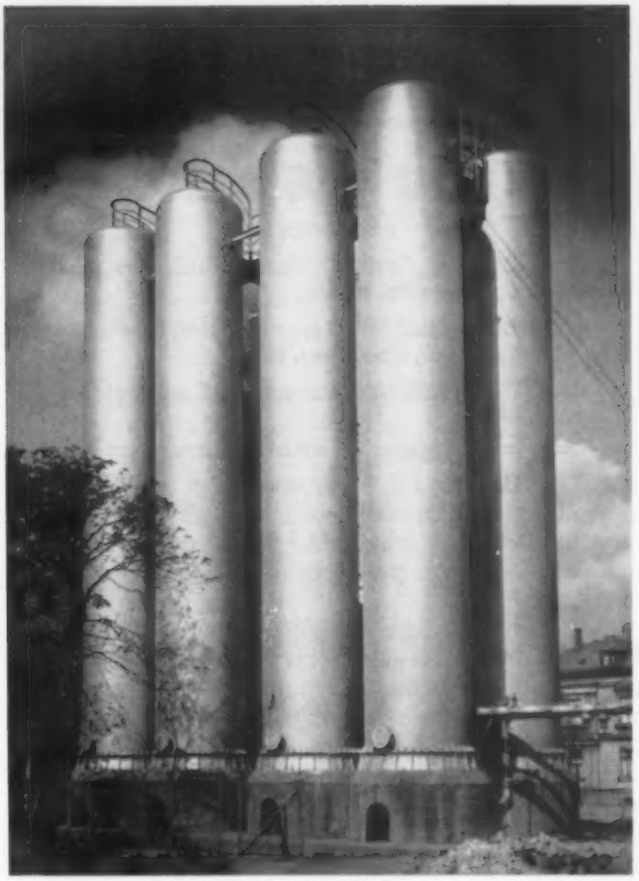


Figure 10 — A storage system of 385,000 cu ft is used with the oxygen plant shown in Figure 9.

The study of these oxygen plants did not cover all in Europe. One very important one in Austria could not be included. However, it was found that the intermittent supply of oxygen to converters and other consuming equipment was being handled from producing units that operate at almost steady loads. Regulating devices for large volume demands from both low pressure gasometers and high pressure storage has been well worked out.

Figures 9, 10, and 11 show several European units.

Figure 11 — Another European plant is shown in this illustration.

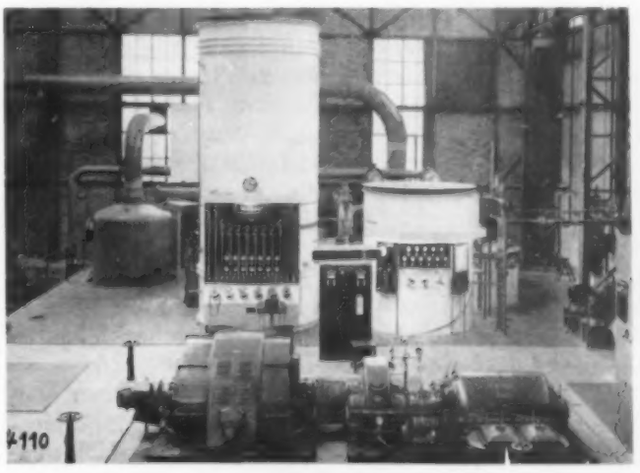


Figure 9 is a large production unit of 110 tons per day of 99.5 per cent product and Figure 10 shows a high pressure storage system for 385,000 cubic feet at the same plant.

DISCUSSION

PRESENTED BY

C. E. DUFFY, Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Md.

R. L. DEILY, Steel Mill Representative, Air Reduction Sales Co., New York, N. Y.

MARTIN J. CONWAY, Consulting Fuel Engineer, Gap, Pa.

C. E. Duffy: At Sparrows Point we have two generating stations, each producing high purity oxygen. Our first station, which has been in operation for approximately five years, consists of four 2500-cfhr units.

Our second station, installed during the past year, has four 7000-cfhr generators. This installation was made for two purposes, (1) to produce oxygen and, (2) to provide a by-product nitrogen to be used for annealing purposes. The nitrogen from the generators is purified; hydrogen added, dried and then used as atmosphere gas in our coil annealing furnaces. The oxygen produced is used throughout the plant to replace purchased oxygen and any surplus, which amounts to approximately 30 per cent, is used for flame enrichment in the open hearth.

R. L. Deily: It is high-school knowledge, but worth repeating, that the steel industry takes ore which is loaded up with oxygen, uses carbon to take the oxygen out of the ore, and then takes oxygen to take the carbon out of the pig iron. The whole industry is based on this oxygen exchange just as our lives are based on it.

Yet so far as the aspects of the oxygen industry that were covered by Mr. Carter are concerned, very little has been said, and it is refreshing to have someone point out some of these facts.

I believe, although I have not worked out the figures in detail too recently, that the amount of high purity oxygen used since 1936 has doubled approximately every five years, which is really a tremendous growth. This increase in oxygen consumption since that date, as well as beforehand, is the result of characteristic American cooperative development between producer and consumer.

In the late 1930's, for example, the use of scarfing and heavy cutting became common to the steel industry. During World War II there was a general increase for use in war production, involving scarfing, heavy cutting, ordinary cutting and other processes. As Mr. Carter pointed out, the greatest increase in production of oxygen occurred in the United States in 1943 and was due primarily to the additional consumption caused by cutting for ship building. Following the short slump in 1945, the production of oxygen has climbed again at a very steady rate, which is due, among other things, to the use of oxygen for metallurgical purposes.

All of these processes that are heavy oxygen consumers, such as scarfing, heavy cutting and metallurgical uses, are examples of these oxygen processes which were developed in common by the steel industry and the oxygen-producing companies.

Now in 1953, the amount of oxygen used by the steel industry has become so great, with the consequent drop in the price, as was indicated by the Figure 1 of Mr. Carter, that new fields of application which had been predicted for years come into view. The following story is of interest in this respect. I have a book in my library that was written by Mr. Claude, who designed one of the first type of air liquefaction units, and this book was written on how he came to design it, and what some of the characteristics were. The date of publication is 1906, and in the preface to this book there are comments by a friend of Mr. Claude, in which are described in glowing terms the potential metallurgical uses and the tremendous future of industrial uses of oxygen. And these men in 1906 are really enthusiastic, just about as enthusiastic as some of us in the oxygen industry are in 1953, nearly 50 years later. It has taken the sharp increase in oxygen usage since 1936, with consequent tremendous distribution and relatively low price, to put oxygen availability where the new fields of application that were described as long ago as 1906 are finally becoming economically feasible.

One further comment to give figures on oxygen consumption. In 1936, a typical steel mill used possibly 8,000,000 cubic feet of oxygen a month with only about 1 per cent delivered by pipe line. Today, the same mill will use 20,000,000 feet or more per month with 95 per cent delivered in pipe lines.

The supply and distribution of such quantities of oxygen require specialized engineering, as was sketched briefly by Mr. Carter. It is also important to note that oxygen processes such as de-carb, heavy cutting, scarfing, and many others would not be possible without such piped oxygen. In summary, the use of oxygen now is as common as that of the traditional utilities, and oxygen has, in our opinion, the same status in the mills as steam, water, power, and compressed air.

Martin J. Conway: Mr. Carter's paper is interesting in several respects, especially his reference to the early use of oxygen with acetylene for welding, with oxygen purities in the neighborhood of 95 to 97 per cent.

Mr. Carter makes a prediction that further reduction in oxygen cost beyond the present bulk price of $1.50 per 1000 cubic feet, to $1.00 per 1000 cubic feet for users of 30,000,000 cubic feet per month.

American designed plants have been available for several years, which can be purchased and operated for substantially less than $1.00 per 1000 cubic feet on a 30,000,000 cubic feet per month basis, after making generous allowance for plant write-off, and, as a matter of fact, $1.00 per 1000 cubic feet is readily obtainable on a plant designed to produce 25 per cent of 30,000,000 cubic feet per month. Such plant is inclusive of storage and other necessary auxiliaries.

There is no justification of a leased plant for oxygen consumptions in excess of 240,000 cubic feet per average day, with the possible exception of the controversial feature of tax shelter.

Purchased plants of domestic design, having capacities of from 10 to 1000 tons of oxygen daily, have been in operation in the United States a sufficient length of time to warrant their acceptance by any industry interested in these volumes of oxygen.

DETERMINATION OF THE OPTIMUM CURRENT IN AN ARC FURNACE

By W. E. SCHWABE,
Research Engineer
National Carbon Research Laboratories
Cleveland, Ohio

. . . . overall improvement in electrode and power efficiency can be attained by proper adjustment of the arc current . . . .

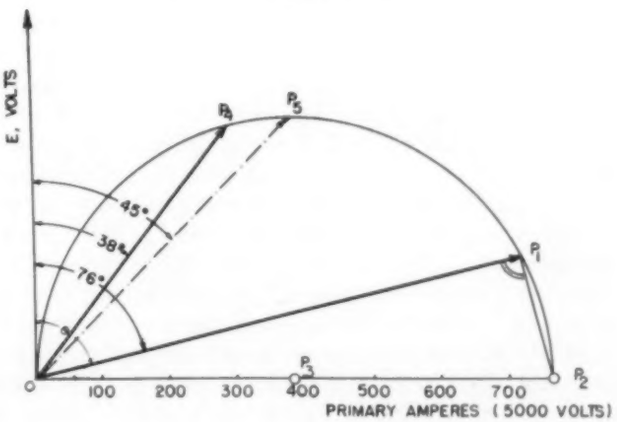
▲THE theory concerning the determination of the optimum current for highest power input to an arc furnace is well known, and has been described by several writers. See for example: V. Paschkis, "Industrial Electric Furnaces and Appliances," Vol. 1, pp. 170-171, 1945, Interscience Publishers, Inc. Briefly stated, this theory requires that with a given transformer-circuit combination, the arc length shall be adjusted so that the electrical resistance of the arc is equal to the impedance of the circuit exclusive of the arc. If the arc be longer than this optimum value, the arc voltage will increase but the current will fall in greater percentage so that the arc wattage is less. Conversely, if the arc be shorter, the current rises, but the voltage drops more, so that again the arc wattage is less.

Although this principle is universally accepted, the methods described for determining the optimum current in practical furnace operation are quite involved and difficult to apply with accuracy. The writer is thus reminded of his earlier experience in Germany, where a much simpler and more practical procedure was applied to various arc furnaces up to 30 tons capacity.

The development of this procedure was the work of an arc furnace committee of an association of German power supply companies. The general objective of this and of other related committees was to effect savings in power consumption, and particularly with arc furnaces, to minimize the load fluctuations which characterize this service. In this arc furnace committee, the writer represented a non-partisan research organization. This group studied the problem of practical furnace operation at optimum current, and developed the relatively simple procedure which will first be described and then mathematically proven in the following paragraphs.

To begin with, short-circuit readings of voltage, current and power are secured with the transformer setting to be evaluated. This is best done after a meltdown, when the electrodes can be lowered into the bath for the few seconds needed to record the resulting short-circuit meter readings. It was always found that the time-delay overload settings of the circuit breakers gave time enough for this purpose. Such readings permit the determination of the phase angle between volt-

Figure 1 — Vector diagram of a 25-ton arc furnace.
Vector OP_1 = Short circuit current — 762 amp— 24 per cent power factor.
Vector OP_4 = Optimum current — 460 amp — 79 per cent power factor.
Vector OP_5 = Maximum total power—545 amp— 70.7 per cent power factor.



age and current, as shown by Figure 1, which is the vector diagram determined for a 25-ton arc furnace. In this figure OE is the voltage vector and OP_1 the current, lagging the voltage by the angle θ determined from the short-circuit meter readings, and the simple relationship

$$\text{Watts} = EI \cos \theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

It is well known that in an electrical circuit of constant input voltage, constant reactance and variable resistance, such as an arc furnace represents, the locus of all possible current vectors lies in a semi-circle, located as shown by Figure 1. Thus, given the current vector OP_1, the appropriate semi-circle is determined by constructing the line P_1P_2, perpendicular to the current vector at P_1, and drawing a semi-circle of radius P_3P_2, with its center at point P_3, half-way between points O and P_2. Then, as a final step, the current vector for maximum arc power is very simply determined as OP_4, bisecting the angle θ and terminating at the circumference of the semi-circle. The use of the semi-circle current locus, and the knowledge that the phase angle for maximum arc power is half that with the arc short-circuited, thus make possible a most simple solution of high accuracy, since the only experimental readings needed are secured under very stable load conditions.

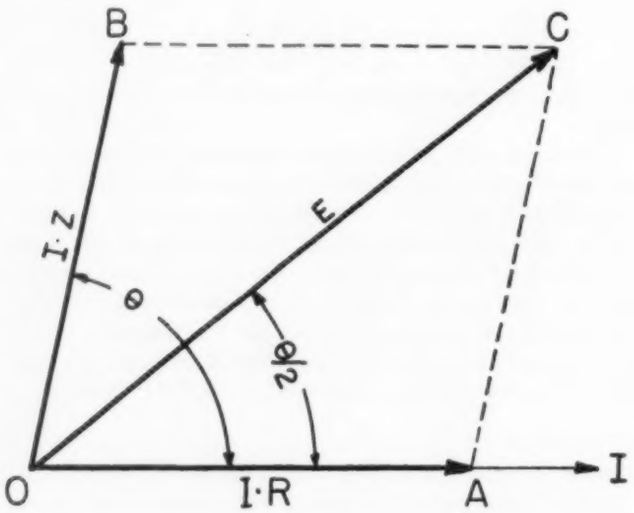


Figure 2 — Vector diagram of arc furnace circuit at optimum current.

Z = Total circuit impedance, exclusive of arc.
R = Resistance of arc.
E = Line voltage.

The half-angle relationship involved here is simply shown by the vector diagram of Figure 2, drawn with reference to the horizontal current vector, OI. The voltage vector OB (= IZ) represents the voltage drop across all circuit elements except the arc, and this leads the current by the angle θ, determined with the arc short-circuited as previously described. The voltage vector OA (= IR), in phase with the current, represents the voltage drop across the arc. The vector sum, OC, then represents the line voltage E. Now for the condition of maximum power in the arc, the resistance R of the arc must be made equal to the combined impedance Z of all the other circuit elements.

Thus $IZ = IR$ ..... (2)
and $COA = COB$ ..... (3)

since they are the base angles of the similar isoceles triangles OBC and OAC.

Finally, since $COA + COB = \theta$, ... (4)
$COA = \frac{1}{2}\theta$ ... (5)

which was to be proved. That is, with an arc resistance R equal to the impedance Z of the rest of the circuit, the current lags the voltage by an angle $\theta/2$, which is half the angle θ by which the short-circuit current lags the voltage.

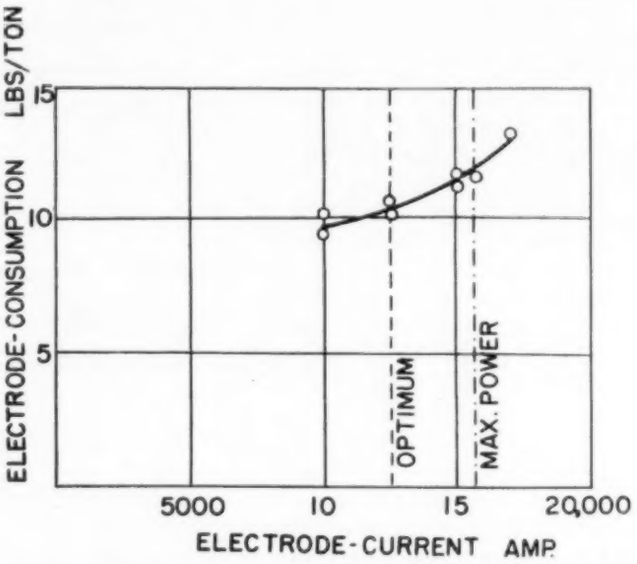


Figure 3 — Electrode consumption vs current of a 20-ton furnace with 14-in. electrodes (graphite), and 210 v tap.

Referring again to Figure 1, the current vector OP_5, lagging the voltage by 45 degrees, has also been drawn to represent the current for maximum total power in the complete furnace circuit. It is well known that this is secured when the total circuit resistance is made equal to the total circuit reactance, to give a phase angle of 45 degrees as drawn. It is worth noting that the current of 545 amperes so determined will in fact generate less heat in the furnace than the optimum value of 460 amperes; at the same time, circuit losses are increased by about 40 per cent and electrode consumption by perhaps 10-20 per cent, both while melting less steel. Current values for this example were recorded as read in the primary high voltage circuit, whereas in a later example (Figure 3) the arc current itself was recorded. Figure 3 shows electrode consumption data taken on a different furnace, where the consumption at maximum total power is 17 per cent higher than at optimum current, or maximum arc power. Important savings in power and in electrodes are thus possible with electric arc furnace regulators set to maintain optimum current.

In the writer's earlier experience in Germany, furnace regulator adjustments were made for a given tap setting while arcing to a molten bath of maximum arc stability, the mechanism being adjusted as required to maintain the optimum current determined by short-circuiting the arc. During the melt-down period, the meters oscillate so rapidly and so widely that accurate adjustment is not possible. Once adjusted under more

stable conditions, however, the controls operate during the erratic melt-down to yield an overall improvement in electrode and in power efficiency such as the theory predicts.

DISCUSSION

PRESENTED BY

T. B. MONTGOMERY, Engineer in Charge Control Division, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

D. R. COCHRAN, Application Engineer, General Electric Co., Schenectady, N. Y.

E. H. BROWNING, Manager, Metal Working Section, Westinghouse Electric Corp., East Pittsburgh, Pa.

W. E. SCHWABE, Research Engineer, National Carbon Research Laboratories, Cleveland, Ohio.

T. B. Montgomery: This method of setting the circuits to match the arc drop to the impedance instead of the total IR drop of the circuit to the impedance is of value.

In examining this paper it seems to us that the simple procedure that he has described here would enable us to determine the optimum current for maximum arc wattage in much less time than by measuring the arc voltage and watts for varying currents on each of the furnace taps as has been the practice of most of us in the past.

Potential connections could be made at the transformer terminals instead of at a point as near the arc as we can get conveniently. Normally it is a little difficult to get close to the arc, and we always have the electrode drop to contend with.

This of course considers the circuit from a theoretical standpoint, and I would like to present the thought that as electrical manufacturers, we have tried to get the electrical circuit as efficient as possible, and as electrical engineers, considered it from that point of view. It seems that our difficulty has been in tying in—since our point of view is purely the electrical circuit—the best operation or the best adjustment of the electrical circuit, when tied to the metallurgy and operating furnace practice. For that reason, without at all detracting from the use of this method, we perhaps should keep in mind that from past experience, the optium current for maximum arc wattage does not always represent the current for the optium furnace operation.

For example, with certain types of scrap, it may be desirable to have a longer arc, to insure a better and quicker melt down, than if we had the most efficient conditions in our electrical circuits. Also, a longer arc may be desirable when making certain types of alloys, particularly in those cases where we want to minimize the carbon pick up. That leads us, in the use of this method, to suggest that we need to go further in tieing our electrical circuit to the actual operating requirements.

D. R. Cochran: The half-angle relationship which Mr. Schwabe has discussed should be very useful for those who want to be sure that their arc furnaces are being operated at the maximum efficiency consistent with the desired production. However, this method will not give 100 per cent accuracy, because it ignores the circuit impedance between the infinite bus and the point where the power factor is measured. There is another method which does consider the impedance between the point of measurement of the power factor and the infinite bus, and in cases where this value of impedance is high, the other method should be used.

The need for determining optimum current in an arc furnace is widely misunderstood and clarification is necessary. The optimum current phenomena is not peculiar to an arc furnace. It is present in any circuit, either a-c or d-c circuit, optimum current occurs when the impedance of the load is equal to the impedance of the remainder of the circuit. In an arc furnace, the arc can be represented as an adjustable resistance, and optimum current then occurs when the arc resistance is equal to the impedance of the remainder of the circuit.

As an example, a circuit with an adjustable resistance for a load is an incandescent lamp load on a generator or transformer, where more lamps can be added to increase the load. In this case, when the resistance of the load is equal to the circuit impedance, optimum current will also occur. However, because the circuit impedance is very low, optimum current will occur at extreme overload conditions. Obviously the load should be based on the rating of the generator or transformer and not on a so-called value of optimum current. The same is true for an arc furnace. The load should be based on the rating of the furnace transformer, and not on the so-called value of optimum current. Perhaps the word "optimum" is over-used. It may be advisable to coin a better word.

It is well known that reactance is required in an arc furnace circuit to give arc stability. It has been found in practice that good arc stability can be obtained with enough reactance to give approximately 85 per cent power factor at full load on the furnace transformer. With this amount of circuit impedance, optimum current occurs at about 130 to 140 per cent of the furnace transformer rating.

Herein lies the value of determining optimum current. It enables the furnace user to be sure that the stabilizing reactance being used is at a minimum value required for good arc stability.

Minimum reactance is desirable because it gives higher power factor, higher electrical efficiency, and more arc kilowatts for a given value of arc current because more voltage is available at the arc. It also decreases the electrode consumption as Mr. Schwabe pointed out. All of these things are very desirable.

During the melt-down period, the furnace transformer may be operated up to about 120 per cent load for faster melting. When the proper amount of reactance is being used as determined by finding what

the optimum current is, overloading the transformer for fast melting will still permit operation below optimum current and at an efficient point.

The premise that 70.7 per cent power factor is correct for furnace operation is false. Optimum current, as it has been defined does not occur at that point. The thing to remember is that it is desirable to have the stabilizing reactance at a minimum consistent with good arc stability. In practice, it has been found that this amount of reactance will give approximately 85 per cent power factor at full load. It is also important to remember that the arc current should be determined by the rating of the transformer and not by the so-called "optimum" current. When "optimum" current has been determined, it aids in intelligent selection of the proper voltage and reactance taps so that correct furnace operation can be obtained.

E. H. Browning: I would like to state that I think Mr. Schwabe has done a very fine job in putting before this group the necessity of knowing the characteristics of any given electric arc furnace.

Maybe, as has been pointed out, the definition of the word "optimum" is open to a little bit of argument; but generally the real meaning of the word is that value of the pertinent quantity which will give the fastest melting down of the steel and the greatest production at the minimum kilowatt-hour consumption for any particular case. That is what you are hunting for.

Along with that, there might be other factors having to do with demand and power factor of operation, that would indicate that you should operate at values less than this so-called optimum current, but in no instance should you ever be above that value. I know a number of steel companies have spent considerable time examining their furnace circuits to determine just where this optimum point is.

Mr. Schwabe's method of determining that optimum point is at least unique in presentation here. There are other methods. One method that has been practiced was that of actually taking a furnace heat while it was in production at flat bath conditions and gradually reducing the current at each particular tap voltage while taking plots of arc current, arc voltage and kilowatt input. From this date you can plot a curve which gives you the basic curve for the furnace circuit, but not the basic curve for the power input to the arc. By setting arc currents perhaps five to ten per cent less than that value giving maximum input, and pretty good log record of your kilowatt-hour consumption per ton of steel produced, you have a reasonably practical way of finding out just how close or how far away you are from the optimum point. There certainly have been other methods used in addition to this. I know of one instance where electrodes were placed flat down on a piece of steel in the bottom of the furnace and tests conducted to try to evaluate the resistance and reactive values for each part of the circuit, and I think that was certainly a forward-thinking manner of looking into furnace characteristics.

In the past five or so years, equipment has been developed which has aided the producer of electric furnace steel by permitting him to set his control at these optimum points for each furnace tap such that he realizes best production from the furnace.

Generally, the larger furnaces are the ones that are affected most by not operating at the optimum point. The smaller furnaces, although it is just as important that you operate them properly do not present the limitations the larger ones do. One reason for this is that smaller furnaces generally use transformers provided with adjustable supplemental reactors. Thus, the characteristic of the smaller furnace's circuit can be adjusted more readily than that of a larger furnace which usually has a fixed inherent minimum reactance.

W. E. Schwabe: It is recognized that the commonly accepted term "optimum current" does not always define the best current for a particular furnace operation. However, it does define, as Mr. Browning points out, a maximum current value which on no account should ever be exceeded. It thus gives the operator a calibration point which serves as a useful reference for any other intended point of operation.

Mr. Cochran points to the inaccuracy of ignoring the impedance between the point of measurement of the power factor and the infinite bus. Where this is known, it can be recognized in the half-angle calculation as well as in any other. However, this transmission line impedance factor is in many cases a variable one, dependent upon interconnection variables controlled by the power supply companies, and so difficult for the furnace operator to take into account. In any case, a high precision in the determination of optimum current is not useful in view of the wide current fluctuations unavoidably encountered in practice.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

NEW OPEN HEARTH FURNACES AT STELCO

By E. T. W. BAILEY
Chief Combustion Engineer
The Steel Company of Canada, Ltd.
Hamilton, Ontario, Canada

. . . . open hearth shop described is one of the most modern now in operation . . . .

▲ IN 1950, it became apparent that if Canada were to maintain her present rate of growth she would need increasingly large amounts of implements, tools and machines, all of which require increasingly large amounts of steel. Stimulated by national alertness and the opportunities which are the heritage of that vigorous young country, this growth and development was proceeding at an accelerated pace. To meet this need, the Steel Co. of Canada, Limited embarked on a large plant expansion program. Recently completed, the new facilities included docks, coke ovens, blast furnace and the new open hearth shop, which will be described in this paper.

The site selected was adjacent to the existing No. 2 Shop. The ground had been reclaimed by slag filling water lots which had at one time extended into Hamilton Harbor. The shop and its approaches cover an area of twenty acres. The main building, consisting of four bays, is 784 feet long (Figure 1). The first bay on the right is the stock bin building. Adjoining it is the scrap handling bay. In the main bay, second from left, are located the charging and pouring aisles for the four 275-ton furnaces. On the left, separated by a double track ingot run, is the mold preparation bay. The shop is laid out so that it can be expanded to eight furnaces with maximum handling efficiency, or for ten furnaces at some sacrifice in this respect.

The stock bin bay contains miscellaneous materials such as ore, limestone and dolomite, which are handled by bucket crane out of the bins to service tracks at floor level. The scrap handling bay is 102 feet wide. The seven adjacent tracks are at charging floor level. Two of the tracks are for gondolas loaded with scrap, so that one track may be switched, while loading into charging buggies continues from the other. Two tracks between the gondola tracks are loading tracks for charging buggies, and here again loading continues on one track while the other is switched. These buggies are equipped with four 44-cu ft boxes and, after being loaded, are weighed automatically as they pass over a track scale and are pushed back through the 52-ft wide scrap loading building on one of the three remaining tracks. Two of these tracks are utilized as storage tracks for loaded buggies while the third, nearest to the furnace, serves as a running track. With these storage tracks and three crossovers into the charging track a steady flow of lime, ore and scrap can be maintained.

The furnace building consists of six 112-ft spans. Due to the heavy loading, the longitudinal bracing along the center row of columns is of a very unique design in that all knee braces between crane girders and columns have been omitted. All longitudinal forces from the cranes and wind are transferred through the roof bracing into the two outside rows of columns, thus allowing for free deflection and rotation at the ends of the crane girders under load, as well as allowing for free expansion or contraction of the building without causing any excessive stresses in the structure. The furnace aisle is 84 ft wide.

The empty span at the trestle end accommodates the emergency hot metal entrance, a truck ramp, and space for miscellaneous mechanical and refractory work at floor level. The empty span at the other end, which will be the eventual middle of the shop, accommodates hot metal transfer, a 10-ton hydraulic elevator, a stopper rod furnace and hot metal ladles.

The cellar area under the scrap handling lean-to is used for material storage. This area is completely paved

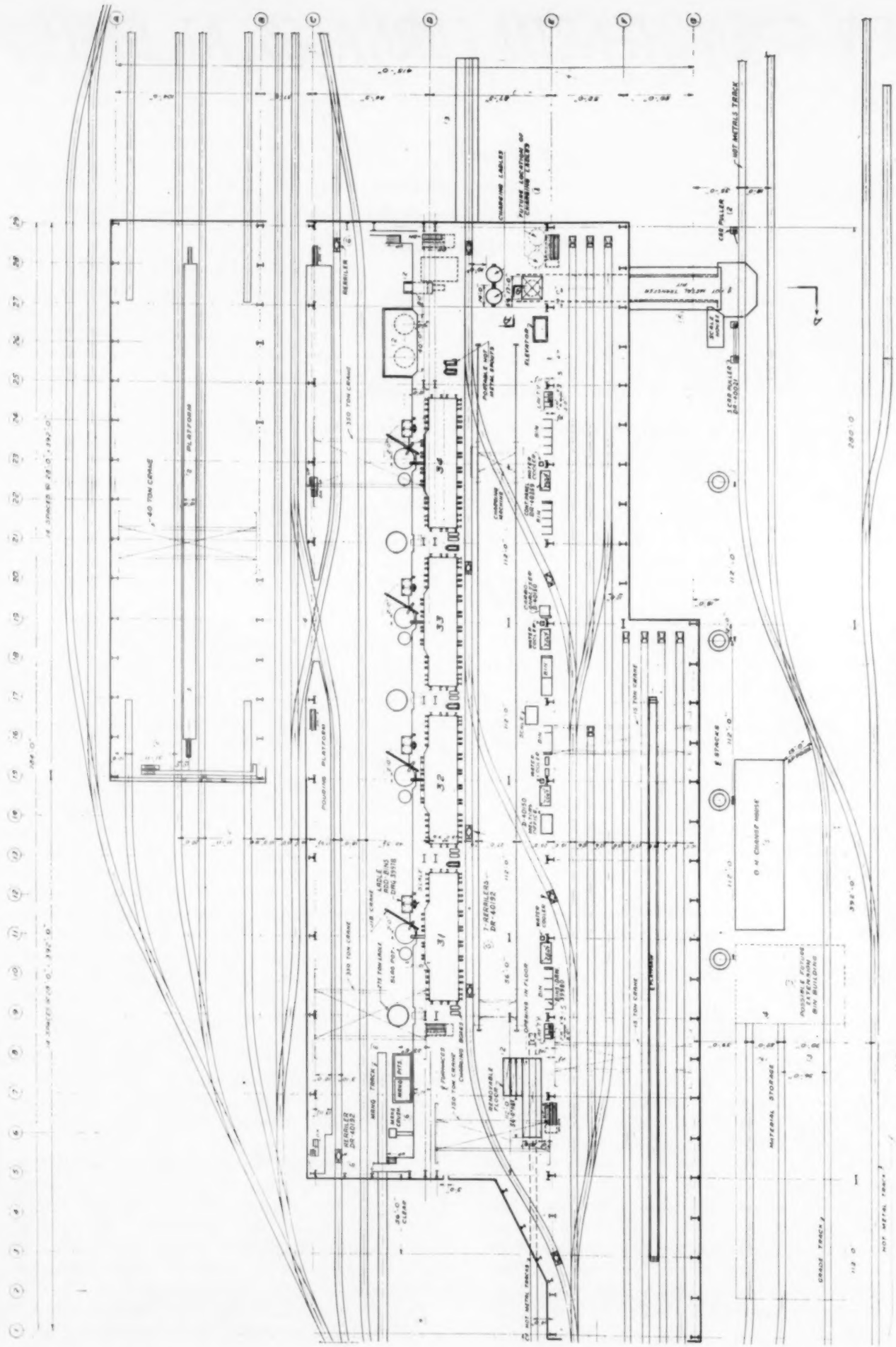


Figure 1 — Layout shows No. 3 open hearth shop at Steel Co. of Canada's Hamilton, Ontario plant.

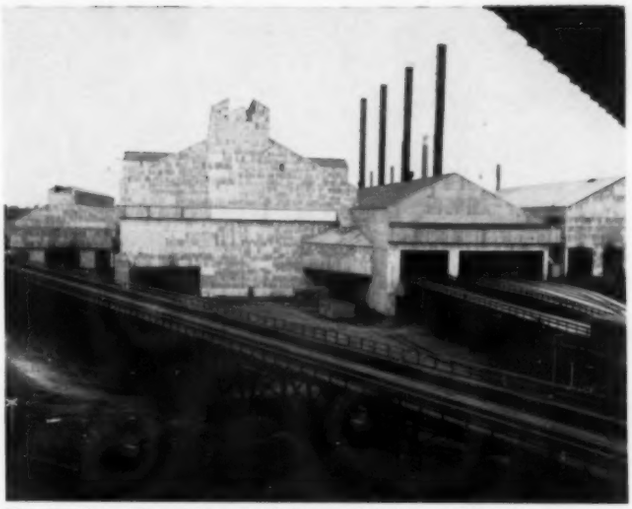


Figure 2 — The main building which consists of four bays is shown from the west end.

Figure 3 — Scrap preparation bay is 52 ft wide.

and includes a depressed track, a clear roadway its entire length, which will accommodate large trucks, and bins, capable of storing 3,500 tons of manganese, silicon, pig silicon, aluminum, etc. There is ample room for storing approximately 60 cars of palletized materials, such as brick.

The facilities for crushing alloys are located at the charging end of the open hearth pit. They consist of a spur track adjacent to a 12 x 24 in. jaw crusher capable of crushing to 2 in. and down at a rate of 20 to 25 tons per hour. The crushed alloys are taken from the crusher by conveyors and deposited in transfer boxes with which the crane can fill storage bins on the tapping platforms capable of holding a three-day supply.

The hot metal from the blast furnaces is transported in six 200-ton mixer type ladles to a hot metal station located at grade on the charging side of the building (Figure 5). It is poured from the mixer ladles into a 100-ton open ladle on a transfer car which rests on a scale. It is then transported by car puller along a depressed runway to a point under the charging floor where a hole is provided through which the hot metal crane can raise the ladle to charging level and pour into the furnaces.

Scrap is charged by two 12-ton charging machines. A bucket loader and lift truck are also provided for floor work.

A 20-ton platform scale is located centrally on the floor as well as a weigh scale for ladle additions at the back of each furnace. The hopper, on the platform of the scale, is loaded by gravity from crushed stock bins and transferred by powered jib cranes to the ladle addition chutes.

Slag is handled in 450-cu ft steel pots on double pot cars. The furnaces are designed to flush front and back, the front flush being caught in the slag pot on a carriage, the position being controlled from the operating panel. The carriage operates on a runway elevated 6 ft above the pit cellar level which allows for overflow clean-up without interfering with its operation.

The stopper rod preparation equipment (Figure 6), consists of a rod straightening press, a make-up room, an upending table and a vertical gas fired drying oven. The upending table is designed so five complete stoppers can be rolled from the make-up room and fastened to the upending table by means of a small four-wheeled carriage. The table is then upended by means of a motor and gear unit, in such a way the carriages are dis-

Figure 4 — Room is unusually ample in the open hearth layout.

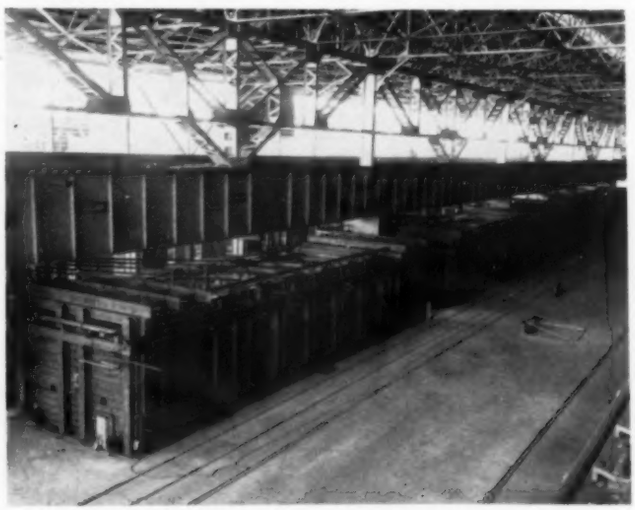


Figure 5 — Illustration shows layout for hot metal transfer.

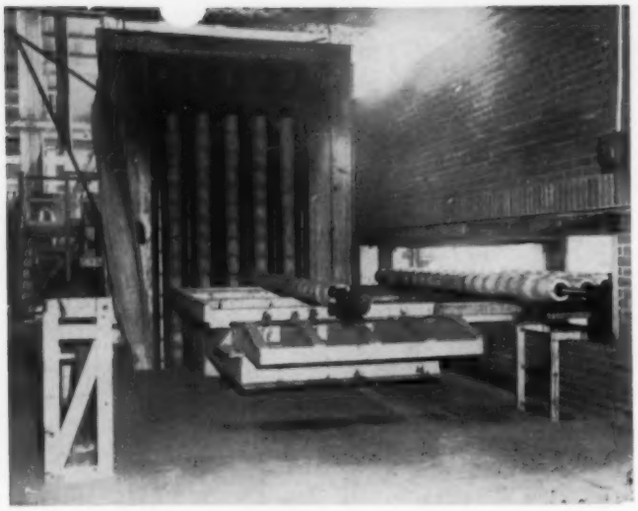


Figure 6 — Table is designed to upend five complete stoppers at one time.

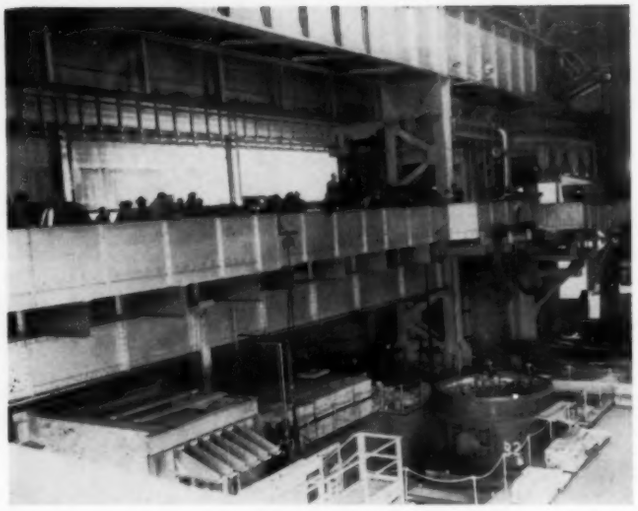


Figure 7 — Ladle preparation facilities are concentrated in this area.

charged onto tracks running through the drying oven. This eliminates exerting any bending strain on the stoppers which might crack or crumble the sleeves after the rods are made up. The oven has a capacity of approximately 100 stoppers. As each five stoppers are introduced at the charging end of the oven, they push five stoppers out into the open on the pit side where they can be picked up by the pit crane, and the carriages returned for re-use by an inclined track along the side of the oven.

Ladle preparation facilities consist of a stand in which the ladle can be tipped, a platform from which the ladleman can change nozzles, and an air-operated prop which is moved under the ladle when in a horizontal position, allowing the crane to be freed while the ladle is being serviced.

The conventional type of open hearth building is often ineffective in adequately distributing air to the principal working areas and the draft head or stack effect of the high monitor is greatly reduced by openings high in the side of the building. In order to overcome this condition the Stelco open hearth was designed with the openings in the sides of the buildings as low as possible to the charging floor, cellar and the pit, and are proportioned so as to equal the area of the opening in the monitor, in order to produce the required jet effect of the incoming air so it will be properly distributed to the working areas.

It is considered that facilities will allow top furnace melting capacities with approximately 60 per cent hot metal and average scrap loading per buggy of 15,000 pounds.

The principal dimensions of the furnace system are given in Table I. The burner is the adjustable angle artillery type designed to burn gas and/or oil (Figure 8). The burner tip is about five inches short of the bridge wall. The gas is admitted concentrically around the oil which gives a greater gas turndown range than would be possible than if it were admitted separately. The furnace ends are of basic suspended construction as is the roof directly over the uptakes. The uptakes are single and flare out above and below the bridgewall to full dimensions allowed by the steelwork.

Three furnaces have a double pass checker system and one, a single pass. All furnaces have steam dust blowers throughout the flue system, and the checker chamber pit is constructed so as to provide access on three sides of each chamber.

Each furnace is equipped with a waste heat sectional header, cross drum, three-pass type boiler complete with superheaters. The design pressure is 400 psig. They operate at 275 psig and are capable of producing 25,000 pounds per hour of steam at 514 F total temperature.

The forced draft fans have a capacity of 30,000 cfm each at a pressure of 5 inches water gage, and are driven by 40-hp motors. Volume is controlled by fan inlet vanes and measured through a Venturi tube located in the outlet duct. The induced draft fans have a capacity of 94,000 cfm each at a pressure of 14.6 inches, water gage, with gas at 600 F and are driven by 300-hp motors. The stacks are 225 ft high.

The charging track in front of the furnaces, the charging machine rail nearest the furnaces, and the pouring floor track are a special 276-pound section and are shaped like a billet with flanges on the bottom so that spills of iron or steel will not stick, as they do around the heads of standard rails.

The entire pit is paved except around ladle stands.

CONTROLS AND INSTRUMENTATION

The furnaces are equipped with a complement of automatic controls that together or separately perform the following functions:

a. *Furnish and maintain the thermal input* set by the operator when fueled with oil alone or with coke oven gas up to 75 per cent of total requirements.

b. *Vary the oil and gas ratio* in accordance with the availability of gas, thereby maintaining constant gas pressure for the plant system. This feature is extended to thirteen of the largest open hearth furnaces. At all times, flow of available gas to the furnaces is not set less than 40 per cent of the re-

TABLE I

Capacity, net tons	275
Bottom construction	
Sintered magnesite — in.	½
Ramix — in.	15
Burned or unburned chrome magnesite (basic brick) in.	21
Fire clay brick (first quality) — in.	5
Plastic insulation — in.	3½
Bottom steel	
Longitudinal I-beam, size in.	24
Longitudinal I-beam, spacing — in.	21
Cross beam, size — in.	12
Cross beam, spacing — in.	22
Bottom plate, thickness, in.	¾
Roof	
Span — ft-in.	23-4¼ (max)
Thickness — in.	18
Thickness of ribs — in.	22½
Width of ribs — in.	6
Spacing of ribs — in.	24
Included angle, degrees-min	57-24
Roof arch radius, center of furnace — ft-in.	24-2 11/16
Roof arch radius, throat — ft-in.	16-11 11/16
Roof arch radius, end of furnace — ft-in.	16-11 11/16
Roof arch rise, center of furnace — in.	3
Roof arch rise, throat — in.	3
Roof arch rise, end of furnace — in.	3
Buckstay spacing — ft-in.	2-7 and 9-8 between pairs
Span of skewback between buckstays — ft-in.	6-10
Type of buckstays	Two 6 x 16 water-cooled slabs
Backwall	
Type	Sloping
Height, foreplate to skewback — ft-in.	5-1½
Brick thickness — in.	15
Granular material thickness — in.	6
Front wall	
Height, foreplate to skewback — ft-in.	5-1½
Number of doors	5
Height of door — ft-in.	4-6
Width of door — ft-in.	5-1
Lengths	
Bath — ft-in.	59-8
Furnace — overall, ft-in.	91-0
Roof, horizontal end section — ft-in.	None — sloping end section
Roof — down slope — ft-in.	15-6
Roof — up slope — ft-in.	None
Roof — horizontal main section — ft-in.	58-0
Throat and bank, air — ft-in.	11-6
Throat and bank, gas — ft-in.	None
Slope of throat bottom	3:4
Widths	
Bath — ft-in.	16-11½
Throat — ft-in.	17-6
Furnace end, inside — ft-in.	18-6
Heights	
Foreplate to roof crown, center of furnace — ft-in.	8-2
Foreplate to roof crown, knuckle — ft-in.	9-0
Foreplate to roof crown, end — ft-in.	11-6
Depth, foreplate to refractory — in. max	31
Depth foreplate to bottom plate — in.	70½
Regenerator floor to floor plate — ft-in.	38-7
Slag pockets (each end)	
Length — ft-in.	24-4¾
Height — ft-in.	13-11
Width — large — ft-in.	18-6
Width — small — ft-in.	—
Volume — large — cu ft	6,300
Volume — small — cu ft	—
Fantails	
Length — ft-in.	14-9

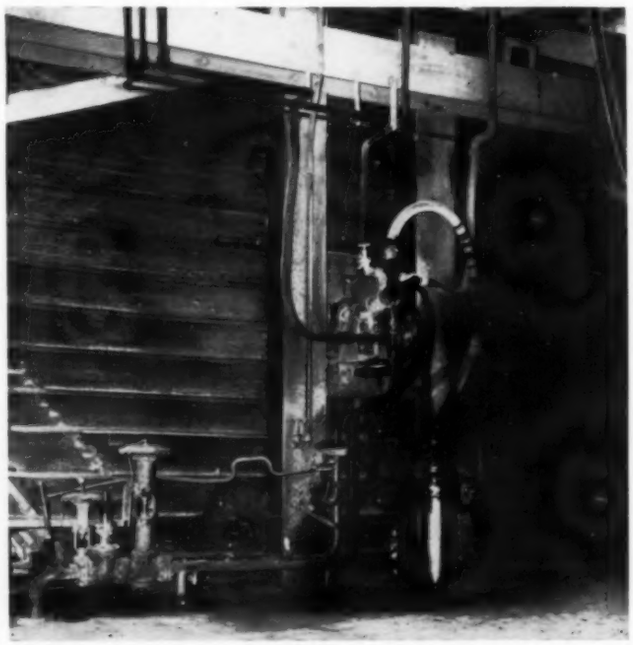
Regenerators (each end)		
No. of passes	2	1
First pass		
Length — ft-in.	14-3	29-6
Height — ft-in.	27-0	27-0
Width, large — ft-in.	25-0½	25-0½
Width, small — ft-in.	—	—
Volume — large — cu ft	9,640	20,200
Volume — small — cu ft	—	—
Checkerwork volume — cu ft	5,750	11,768
Second pass		
Length — ft-in.	10-8½	
Height — ft-in.	27-0	
Width, large — ft-in.	25-0½	
Width, small — ft-in.	—	
Volume — large — cu ft	7,250	
Volume — small — cu ft	—	
Checkerwork volume — cu ft	4,350	

Cross-section areas — sq ft	
At center of furnace	150
At knuckle	155
Fuel inlet port	—
Minimum between knuckle end wall	155
Over uptakes at greatest roof elevation	—
Air uptakes	86
Fuel uptakes	—
Combined downtakes	86
Vertical sectional area — large	77.6
Vertical sectional area — small	—
Fantail, slag pocket end — large	91
Fantail, regenerator end — large	100
Fantail, regenerator end — small	—
Regenerator flue — large	116
Regenerator flue — small	—
Stack flue	46
Stack	44.1
Miscellaneous data	
Kind of fuel	Combined fuel oil and CO gas
Btu per net ton of steel	3,750,000
Lb of steel produced per hr per sq ft of hearth	48
Air supply	Forced

quired thermal input. The operator, at his discretion, can control from 40 to 75 per cent of the total heat requirements in the form of gas.

c. *Proportion and maintain air* for both fuels in the ratio needed to produce best results. Bias and ratio adjustment are provided to produce automatic variation for thermal input rates. Means for independently setting fuel-air ratios for each end of the furnace are also included. The combustion control has hitherto not found widespread acceptance in open hearth application, chiefly because of its inability to take care of air infiltration and leakage. The intensive sealing campaign initiated in most shops in the last few years has reduced air

Figure 8 — Burner is designed to use both gas and/or oil.



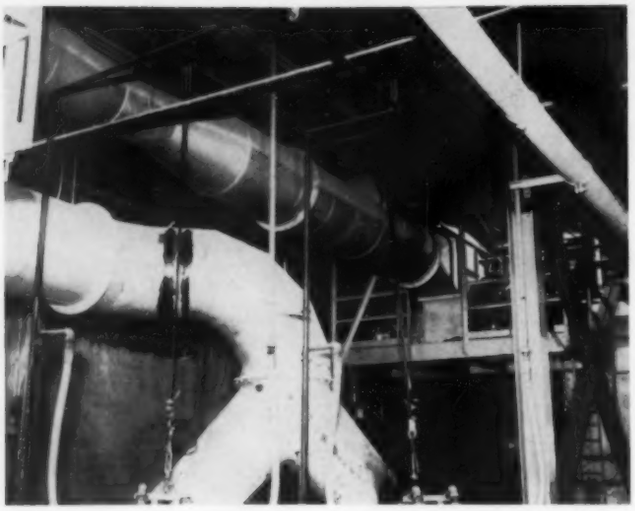


Figure 9 — Forced draft fans have a capacity of 30,000 cfm.

Figure 10 — Induced draft fans have a capacity of 94,000 cfm.

infiltration to a point and a consistency where the useful potential of this control is now almost fully restored. Correction for variance in furnace end conditions for air infiltration now becomes a reflection on the efficiency of the sealing crew and has therefore become a temporary measure. It is amazing how tight furnaces have become.

d. *Vary the atomizing steam flow* to produce the desired bias and ratio with respect to normal changes in oil flow. Changes in oil flow, however, caused by increased or decreased use of gas can be canceled so far as their effect on steam is concerned. Any degree of cancellation can be set and maintained. It was thought at the start that the oil and steam ratio need not be disturbed when gas flows increased in order to maintain flame length. Later, it was discovered gas produced a stretch of nearly invisible flame at the exit end of the furnace, and this was suitably shortened when about two pounds of steam was introduced with every 270 cu ft of gas (equivalent of one U.S. gallon of oil). Flame direction was maintained better and more heat appeared to be released over the hearth. Steam metering and control appear to be well liked and very worth while.

e. *Reverse the furnace* from temperature difference measured in the flues adjacent to the waste gas outlet of the checkers. Reversing can also be done manually or from timers, either on temperature limit or alone. The reversing system is arranged to provide full capacity of both forced and induced draft fans during reversals, which adjustment achieves rapid and complete checker purge. Gas reversing valves are automatically closed on both ends of the furnace when gas flow is zero, thus providing a tight shut-off. It is too much to expect flow control valves to have excellent control characteristics along with tight shut-off. For this reason, also, oil reversing valves are arranged to be manually closed on both ends of the furnace when fettling or as the need arises.

f. *Temperature measurement of roof* was tried but location failed to provide a dependable guide. Flames in view of the sighting element gave, at high firing rates, excessively high readings which did not truly represent roof conditions. The sighting radiation heads were removed to locations judged to be in the hottest portion above the checkers. Two units were provided and their readings were alternately recorded. They sighted into closed end silmanite tubes which were turned 180 degrees in fifteen days and renewed in thirty days. These tubes provide dust-free enclosures and produce temperature readings that are most useful. The instrument is arranged to sound a bell and light a light when the temperature exceeds 2,450 F. At this over-checker temperature, the main roof also appears to be at its maximum safe allowable temperature. This is true in the later stages of the heat and not, for instance, in the early stage where local overheating is caused from scrap deflection. With the aid of a spring return switch, a reading from the sighting tube in the checker providing hot air can be obtained. Many tests have shown these air temperatures are within 50 F of those obtained with velocity couples. The temper-

Figure 11 — Two 350-ton hot metal ladle cranes operate on the pouring side of the open hearth.

TABLE II
Crane Data

No. and type	Main trolley		Auxiliary trolley		Span, ft-in.
	Capacity	Fpm	Capacity	Fpm	
1 — Hot metal ladle Charging side	150	14	40 20	30 36	80-0
2 — Hot metal ladle Pouring side	350	8.3	60 20	20 36	76-0
2 — Stock building	15	9.7	—	—	95-3
1 — Mold building	40	40	—	—	100-0
1 — Ingot stripper Hoist	400 50	7.5 35	— —	— —	60-0
1 — Crane repair trolley	25	25	—	—	10-0
4 — Jib or spout	7½	15	—	—	—
1 — Bin building bucket	15	100	—	—	74-11

ature trends recorded from these locations are most interesting. Plans are completed to use them to control the fuel input to the furnace. By connecting both radiation heads in parallel, a plus average can be obtained. When one controls the fuel input from these temperatures manually—as is now being done—one has to anticipate the amount of fuel reduction to allow before reaching the maximum (2,450 F). If correction is made late, drastic reductions in fuel have to be made in order not to exceed safe temperature and prevent refractory damage. This somehow increases heat times. It seems reasonable that a controller with built-in throttling and reset action can provide the operator with automatic fuel reduction, consistent with the highest allowable temperatures. The operator, it is expected, could set the maximum fuel input rate and the control would anticipate approach to safe temperature and gradually and automatically reduce fuel input to afford the protection needed.

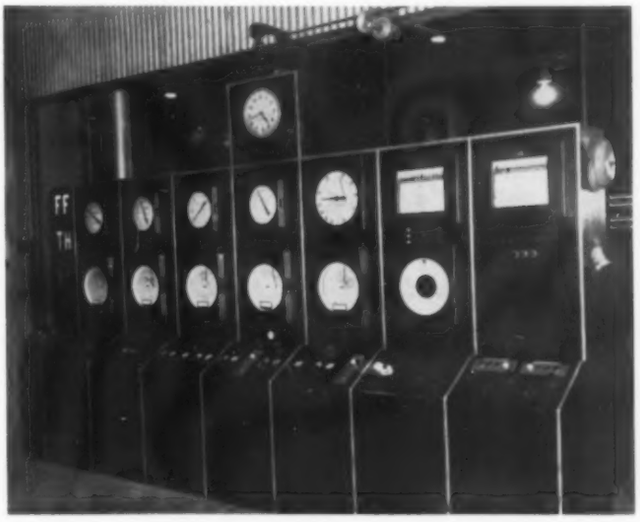
g. *Provide furnace pressure control* within the position limits of the louvre dampers situated at the outlet of the waste heat boiler. Here is a weakness in our mechanical equipment on which some inventive talent should be expended. In order to provide for expansion and dirt damper, clearances are generous and leak unbelievable volumes of gas in their closed positions. Their inherently poor characteristic in near open position in certain locations reduces effective control positions to about 50 per cent of their turning range. They also can affect the gas flow pattern entering the fan so as to seriously reduce its expected capacity and indirectly provide volume control below full opening. Dividing vanes are indicated in some locations. A full study of the combined vane and damper action should be made for each application. Another trouble, charged more directly to furnace pressure controllers, is that their throttling and reset cannot be set for both operating and reversing conditions. During the reversing period, the furnace pressure controller is calling for a completely closed damper. As soon as the timer fully restores the controller to the normal impulse, it functions to close the damper rapidly. Various schemes of locking in control action until the reversing period is over are not completely satisfactory as they cause sway either side of the control point or delay completion of the purge. It has been found that a small tube inserted into the atmosphere impulse line through which compressed air is blown in the direction of the open end produces a false but gentle furnace pressure impulse which calls for a wide open damper. When the control is restored to normal service, its demand for damper position corresponds with the real one. Correction to normal position is made always from the open and not the closed position. Furnace blowing after reversals have been eliminated.

h. *Bath temperature* recorders are provided for each furnace.

i. *The panel arrangement* is designed for the convenience of both operators and instrument craftsmen (Figure 12). Indicators are, as far as possible, grouped at the top which allows easier reading at a distance. Recorders are at eye level for reading and chart changing convenience. The standard two-foot sections are divided vertically by aluminum strips. Each section of bath panel and console serves one item. Thus the left hand section is steam then oil, gas, air, furnace pressure and temperature, reversing and both temperature in the order named. The indicators have two pointers: black for flow for easy distant reading, and white for pressure to be seen at close range only.

Experience in gas firing to date has been favorable. The gas is stripped of its sulphur compounds in a desulphurizing plant (Figure 13). This plant has a capacity of 15,000,000 cu ft per day when reducing from 600 to 50 grains sulphur per hundred cubic ft. It can produce 20,000,000 cu ft per day by automatically bypassing high sulphur gas and mixing it with the purer

Figure 12 — Complete instrumentation aids in the operation of the open hearth.



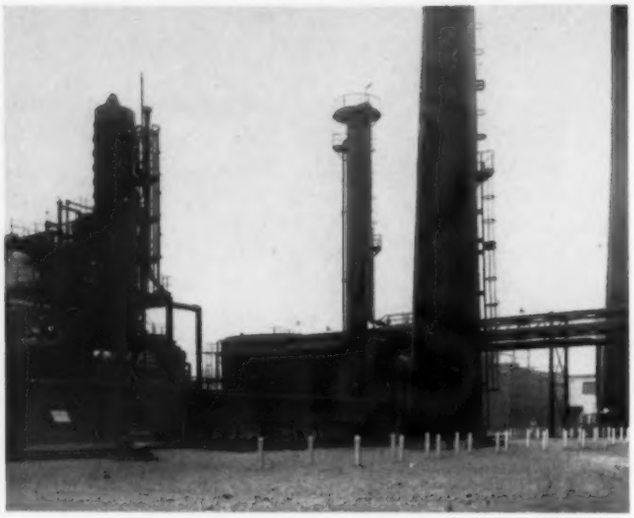


Figure 13 — Before firing, gas goes through a desulphurization plant. Actifier tower is shown on left and absorber tower is shown on right.

gas to a 200 grain sulphur content which approximates that occurring in the fuel oil. In the furnaces, gas seems to produce higher checker temperatures, which in turn produce higher air temperatures. Next to oxygen addition, this is most helpful for rapid melting of the scrap. Also, a high input of low sulphur containing fuel during melting is most desirable as it is then that scrap picks up sulphur from a fuel. Once the melt is under cover, higher sulphur in the fuel does much less damage. The net result is shorter heats insofar as sulphur elimination is concerned. The hydrogen of the gas is thought to assist burning the oil by reason of its high atomic activity.

DISCUSSION

PRESENTED BY

E. C. McDONALD, Superintendent Combustion Dept., Republic Steel Corp., Cleveland, Ohio

A. J. CALLAGHAN, Senior Engineer, Combustion Dept., Bethlehem Steel Co., Lackawanna, N. Y.

E. T. W. BAILEY, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

E. C. McDonald: Have you found that your fuel input per hour or per ton is higher when using a high percentage of gas with oil than when burning oil alone? If so, what is the penalty?

Your paper shows a fuel practice of 3,750,00 Btu per net ton of steel. That is high for a modern furnace tapping 275-ton heats.

A. J. Callaghan: Mr. Bailey has just shown us what good planning and study can do for an open hearth shop. Some shops of tighter dimensions can be slightly envious of a place to work where they left room for your elbows. No doubt we can look forward to some fine production figures from this shop.

Apparently there was some question of the value of double pass checkers over single pass when the furnaces were built. Could the author tell us how the furnace, equipped with single-pass checkers, compares with the others?

The instrumentation program reflects the trend to co-ordinated control of open hearth furnaces. The author's views on fuel-air ratio are interesting and should reopen the question of the value of this control. I wonder if the author has any figures on production, refractory consumption, or fuel efficiency that would show the value of fuel-air ratio control?

The use of checker temperature to automatically reduce fuel input to protect the main roof is relatively new. At our plant we also record checker temperatures, but only as a guide to proper operation of the checkers. We do not find sufficient correlation between main roof and checker temperature to warrant the use of these instruments as controllers. Would the author be able to tell us what factors he feels must be maintained in order to establish this correlation?

This figure of 48 lb per hr per sq ft of hearth area seems on the low side for furnaces of this size. I know of furnaces of slightly smaller capacity producing 58 lb per hr per sq ft of hearth area. Could the author tell us what rate they expect to attain and what problems they have to solve in order to do so?

E. T. W. Bailey: Furnaces equipped with double pass checkers have been found to be sensitive to high firing rates. This shows up in the first or hot pass. Bricks can melt away unless watched or a temperature recorder with alarm is furnished to warn the operator. The single pass checkered furnace has proved less sensitive to high firing rates but has a somewhat lower air heating efficiency.

Combustion air control enables one to repeat fuel-air ratios that have been found to be satisfactory and hold them especially throughout the melting period. The savings cannot be spectacular and for that reason it is practically impossible to divorce its contribution separate from all the other factors.

The idea of trying to limit the heat input from the temperature of the gases leaving the furnace may be new for open hearths but is quite common on soaking pits. We may fail in this attempt but since operators are already using this information to manually adjust the fuel, we may have a chance of success in giving the task to an instrument.

The production figure of 48 lb per hr per sq ft of hearth is figured from tap-to-tap, which is probably in error. The charge-to-tap figure is 56. At year's end this figure has reached 60.

If the majority of the coke oven gas is burnt during the melting period, there seems to be a shortening in overall heat times without any noticeable increase in the calorific value per ton. If it is spread over the whole heat there is some penalty which at present is the subject of investigations.

Fuel practice for a new shop must be discounted until men and machines have been broken in, and the new shop integrated with the rest of the plant operations. At the end of 1953, the monthly fuel value was 3,400,000 Btu per ton.

Figure 1 — Photograph shows site in January 1951 before construction was started.

Figure 2 — Photograph shows site in June 1953 after construction was essentially complete.

REPUBLIC'S NEW OPEN HEARTH FURNACES AT CLEVELAND

By E. C. McDONALD, Superintendent, Combustion Dept., Republic Steel Corp., Cleveland, Ohio.

. . . . unusually good operating records are being obtained in Republic's new open hearth shop . . . .

▲ LATE in 1950 plans were announced by Republic Steel Corp. for the largest single expansion of steelmaking capacity ever undertaken in the Cleveland district. The expansion represented an investment in excess of $75,000,000 to add 672,000 net tons of steel ingot capacity per year to Republic's Cleveland plant.

The major facilities included in the program consisted principally of 126 coke ovens, a 1470-ton per day blast furnace with necessary steam generating and blowing equipment, four 275-ton open hearth furnaces, 21 holes of improved soaking pits to replace and supplement the existing pits, improvements to the 32-in. blooming mill to facilitate the rolling of slabs, (there is also a 44-in. blooming and slabbing mill) a new 72-in. tandem cold reducing mill, and other major changes to provide additional heating, annealing, pickling, and other processing relative to the production of additional sheets and strip.

All these facilities were built into an operating steel plant so there were many operating problems in the district for close to two years.

This paper describes only the open hearth shop and its auxiliaries. The new shop's official designation is number two open hearth shop of Republic's Cleveland district and the furnaces are numbered 21 to 24 inclusive. The other open hearth shop of 15 furnaces is now designated number one shop.

The site selected for the erection of number two shop is adjacent to number one shop. A comparison of photographs taken from approximately the same location show a before and after view looking north. The photograph shown in Figure 1 was taken in January 1951. The photograph in Figure 2 was taken in June 1953

Figure 3 — Sketch shows arrangement of No. 2 open hearth shop with respect to No. 1 open hearth shop and blooming mill.

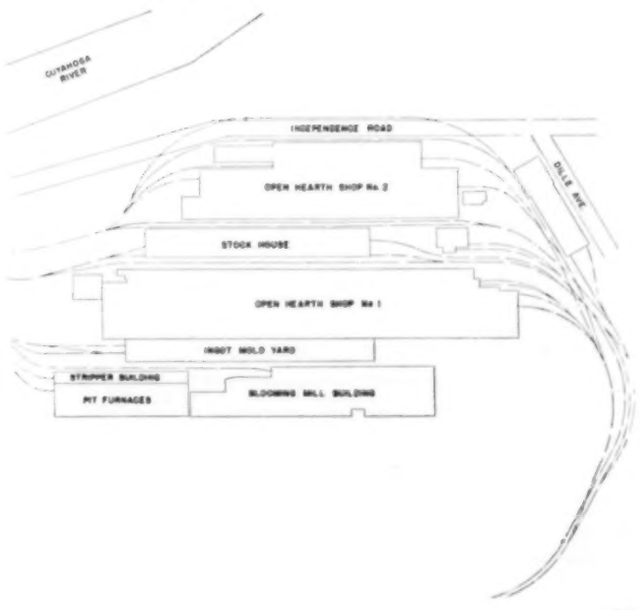


Figure 4 — Charging floor of new No. 2 shop.

before the new building was painted. Figure 3 shows location with respect to other departments. It was necessary to relocate a city street known as Independence Road, rebuild the roll shop and the brick storage buildings, relocate the pattern storage and the carpenter shop buildings, erect a new welfare building for the labor department, and make many changes to the transportation system.

Clearing the site started in February 1951 and excavation began March 5, 1951. The first heat was tapped August 9, 1952 and all furnaces were making steel by October 29, 1952. Figure 4 shows the charging floor after furnaces were in operation.

ARRANGEMENT OF DEPARTMENT

The major parts of the open hearth department are in one main building, as shown in Figure 5 when looking south. The pouring aisle and furnace aisle are in the

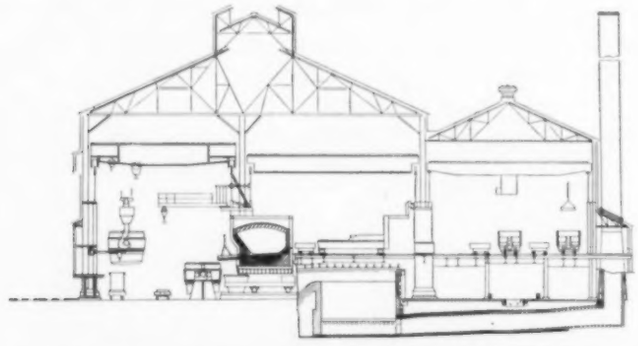


Figure 5 — Section through open hearth building shows arrangement of equipment.

customary parallel arrangement and the stock house is arranged as a third parallel aisle adjoining the furnace aisle. The aisles run north and south. There is a lean-to at the west side of the stock house over the area between stacks that is occupied by the waste heat boilers.

The stock house has a floor at charging floor level over the entire area. There are five tracks in the stock house as shown in Figure 6, two for scrap cars, two for charging buggies and one for running track. There is no space for scrap storage.

Charge materials, principally limestone ore and dolomite are stored in elevated bins of the materials handling system at south end of the stock house and loaded through gates, directly into charging boxes at charging floor level. The materials handling system is described later. Metallurgical and construction materials needed on the charging floor are brought up from the ground floor on a truck elevator at the south end of the charging aisle.

All transportation of charging buggies is on platforms at charging floor level. Incoming scrap in railroad cars is brought over a turnout on the existing incline at number one open hearth plant and over a separate inclined track, as shown in Figure 7, to the charging floor level before entering the stock house.

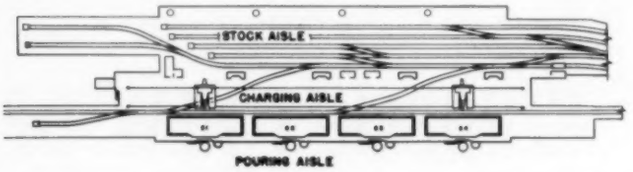


Figure 6 — Floor of stock house is at charging floor level over entire area.

Figure 8 shows track arrangement at ground level. Hot metal is delivered to the open hearth in mixer type ladles at ground level at the north and south ends of the shop. There is no hot metal mixer. Stripping of ingots and mold cleaning is done in an extension of the pouring aisle at the south end of shop.

BUILDINGS

The main building is 862 ft 6 in. long and 240 ft wide. The height to the main crane rails is 56 ft above ground level or 36 ft above the charging floor. The pouring and stripping aisle, running the full length of the main building, is 69 ft between column centers with a crane span of 60 feet. The furnace aisle is 80 ft between column centers with 73 ft crane span and is 805 ft long. The stock house aisle is 76 ft between column centers with 70 ft 6 in. crane span and is 460 ft long. The lean-to aisle, housing the waste heat boilers, is 15 ft wide × 460 ft long.

Figure 7 — Charging buggies are handled on platform at charging floor level.

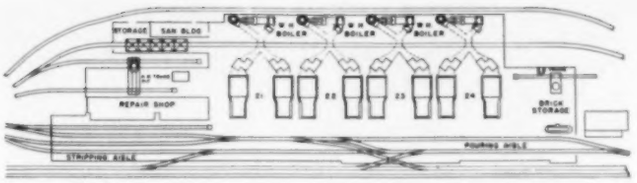


Figure 8 — Sketch shows track arrangement at ground level.

FURNACES

The four stationary, basic open hearth furnaces were constructed with a hearth size and steel and slag holding capacity for nominal production of 275 net tons of steel ingots per heat. The dimensions of furnaces and auxiliaries though were liberal to provide for producing heats of 300 net tons.

The furnaces were installed on 115 ft centers and are of the following dimensions:

Overall length outside of brickwork	97 ft 0	in.
Maximum width outside of brickwork	22 ft 0	in.
Bath length at foreplate level inside of brickwork	63 ft 6	in.
Bath width at foreplate level inside of brickwork	18 ft 7½	in.
Distance from top of foreplate to furnace bottom at furnace center	2 ft 9	in.
Hearth area (brick to brick less corners)	1077	sq ft

All furnaces are equipped for front flushing and have sloping back walls.

Water cooling is used to protect the front and back skewback channels over the hearth. The buckstays in front of hearth are slotted and capped for water cooling. Bridge walls, dog-house roofs and side walls, also, are water cooled, In addition there are hair-pin water coolers at the bottom of the end wall panels at about charging floor level.

FURNACE BRICKWORK

The furnace hearths, of the partially rammed type, have an overall thickness of the bottom at center line of the tap hole of 60 in. The bottoms were laid with 4½ in. insulating brick, 7½ in. fire clay brick, 33 in. chrome brick, and 15 in. rammed ground magnesia.

The roofs of the furnace hearth and port ends were originally laid with 18 × 6 × 3-in. silica brick with ribs of 22½ × 6 × 3-in. brick. The ribs were every fourth ring in the central section of the roof and every fifth course in the remainder of the main roof and in the port end roof. There were no ribs in the sloping section of the roof at the knuckle.

Roof construction was changed after the first run on each roof. Main roofs from knuckle to knuckle were laid with 12 × 4½ x 3-in. silica brick with ribs of 18 × 6 × 3 in. every fourth ring. Along the back walls and extending out from the skew backs 6 ft, a 3-in. dropped section wearing strip of 21 × 6 × 3 in. ribs and 15 × 4½ × 3 in. silica brick was laid with alternate rings of basic brick. The port end and roof slopes were changed to 15 × 4½ × 3 in. silica brick throughout.

The main roof has an arch span of 22 ft 10 in. and rise of 3 ft. The roof at the port ends has an arch span of 19 ft 6 in. and rise of 2 ft 6 in.

There are two 6 ft 1½ in. × 9 ft 9 in. uptakes at each end for a total area of 119 sq ft. Uptake side walls and end walls initially were 22½ in. thick with the exception that the end bulkheads were 18 in. thick. The entire end structure was silica brick.

On first rebuilds, port end side walls were changed to 13½ in. of silica brick with 9 in. of basic veneer on the inside of the walls. Uptake end wall panels were changed to 13½ in. of metal encased basic brick from approximately 2 ft below charging floor level to the top of the burner port. From this point up to roof, 22½ in. of silica brick is used. Front and back walls, which extend 5 ft 6 in. above foreplate level, continue to be basic brick.

The uptake arches beneath the chill box are suspended flat arches 12 in. thick of high alumina fire clay brick.

The furnace slag pockets are single chamber construction 20 ft wide, inside of brickwork, on each end. Silica and first-quality firebrick were used in the walls. The floor consists of layers of silica sand, second-quality firebrick and first quality firebrick. Brick walls of slag pockets are 1 ft 10½ in. thick on the outside end and 3 ft 4½ in. on the inside end. False walls were also provided.

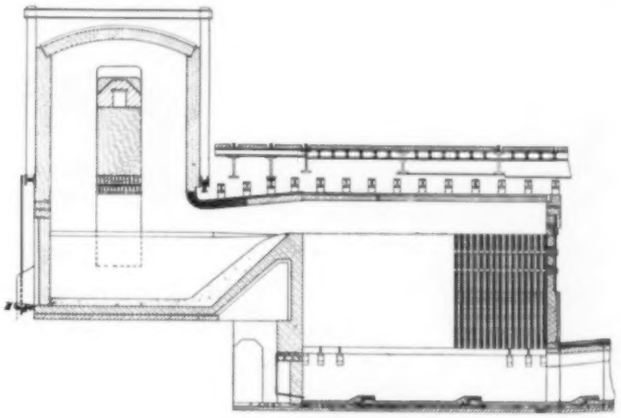


Figure 9 — Elevation shows section through slag pocket and regenerator.

The fantail roofs are suspended, high alumina fire clay brick, 12 in. thick. Material in the noses is suspended, high alumina brick, 12 in. thick. The bridge walls are supported on structural steel chills as shown in Figure 9. An opening under the bridge wall chills was provided to permit cleaning underneath the regenerators and to accommodate soot blowers.

The regenerators are of one pass design and consist of a single chamber with division wall to the top of the checkerwork on each end of the furnaces. The total volume of checker construction on each end of the furnaces is 32 ft 10½ in. long × 16 ft 1½ in. high × twice 13 ft 7½ in. wide. This gives a checker volume on each end, from the top of the rider arches to the top of the checkers, of 14,445 cu ft. Checker construction of 9 × 4½ × 3 in. brick is laid up to provide chimney flues with 7½ in. square openings.

The regenerator chamber walls, including 4½ in. of insulation, are 22½ in. thick, and the suspended flat roofs are 10 in. thick. Openings are provided in the chamber bulkheads and horizontal checker flues for steam lancing. The steel work, brickwork and founda-

tions are designed for 3-pass checkerwork at a future date. Figure 10 shows plan view of checker chambers, slag pockets and furnace.

Furnace flues between regenerators and reversing valves are 6 ft wide and have a maximum height of 7 ft on the inside. Flue roofs are of arched construction. After the reversing valves, the individual flues are 7 ft 6 in. wide and the common flue is 8 ft 6 in. wide. Both flues are 7 ft 6 in. high on the inside. The flue to the waste heat boiler and the flue to the stack are each provided with a damper. The floor of the flues is 15 ft 4½ in. below yard level at the checker chambers and slopes upward to 11 ft below yard level at the base of furnace stack making a slope of ½ in. per ft.

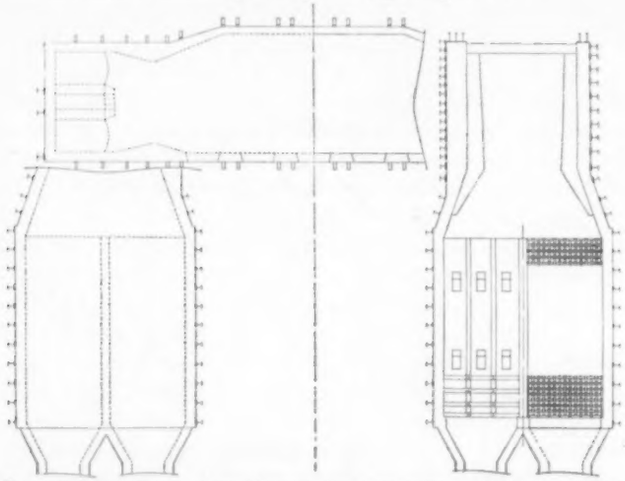


Figure 10 — Plan view shows arrangement of furnace and regenerator chambers.

DRAINED FLOOR SYSTEM

The regenerators and waste gas flues are provided with a water-tight steel pan, drained floor system and sump pit. The drained floor is constructed of common brick with drainage openings on top of foundation concrete. Drainage openings slope under regenerators toward the bulkhead end and under flues toward the same point. From this point they are drained from each end of the furnaces through tile to a sump pit located at the furnace center line. Each sump pit is provided with a pump of 500 gpm capacity at 40-ft head, set at a predetermined water level to keep the system dry automatically. The sumps of all furnaces are connected for flexibility of drainage. A steel pan above the drained floor is constructed of ¾ in. steel plate, watertight design, and is located outside of the regenerators, and outside the flue floor and wall brickwork.

CHARGING DOORS, FRAMES AND BOXES

Each furnace is equipped with five water cooled, electrically operated doors, each 6 ft wide × 5 ft 3½ in. high. Water cooled door frames 6 ft 11 in. wide × 7 ft 7 in. high have a charging opening of 5 ft 4½ in. wide × 4 ft 10 in. high. Charging boxes of 48-cu ft capacity are carried four to a buggy.

REVERSING VALVES AND DAMPERS

Each furnace is equipped with four reversing valves and with two dampers, one to the stack and one to the waste heat boiler. Each reversing valve as shown in Figure 11 is of the regulative double deck, vertical slide type with water cooled damper and valve seat. The upper opening, for the passage of combustion air to the furnace, is 6 ft wide × 2 ft 6 in. high and the lower opening, for the passage of waste gases to the stack, is 6 ft wide × 6 ft high. In addition to the 36-in. flange connection for attachment of the air duct, each valve is provided with an auxiliary air inlet 3 ft × 6 ft for admission of atmospheric air when the forced draft fan is not operating.

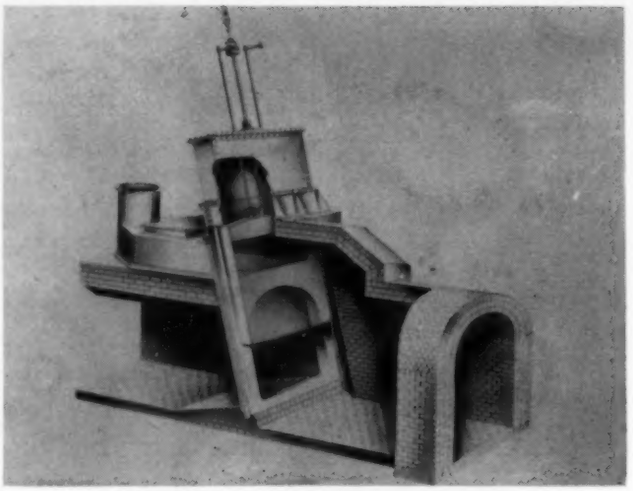


Figure 11 — Reversing valves are of the double deck type.

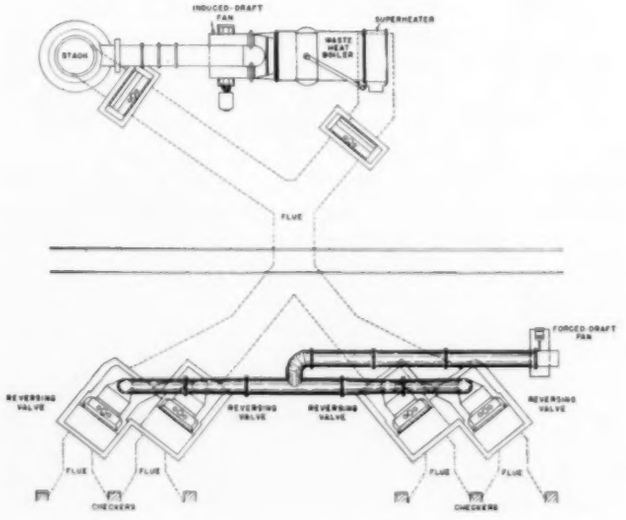
Each reversing valve is independently electrically driven through a worm gear reduction.

Each furnace also is equipped with two water cooled, damper type stack valve units, one for the flue connection to the stack, and one for the flue connection to the waste heat boiler.

FUEL BURNERS AND COMBUSTION AUXILIARIES

Fuel burners of the combination liquid fuel and gas type are located in a dog-house having a water cooled nose. Burners also have a water cooled nose and are

Figure 12 — General arrangement of reversing valves, waste heat boiler and forced air ducts.



equipped with supports so flame direction can be varied by moving the burners. Each furnace has a thermostatically controlled fuel oil heater and temperature is indicated on the furnace control panel. Gas burner design at present is undergoing many design changes due to experimentation for burning large quantities of coke gas. However, in all designs, the gas burner is above the oil burner. Gas pressure in the open hearth is 7 lb, the highest obtainable with existing compressors and piping.

Each furnace is provided with a fan as shown in Figure 12 to supply combustion air. The capacity of each fan is 25,000 cfm at 5-in. of water gage pressure. The fans are equipped with inlet vane control and driven by a 60-hp, 440-v, 60-cycle motor.

Stacks are 8 ft in diameter inside brick lining and 225 ft high above the foundation.

Steam soot blowers are installed in the passages between the rider walls beneath the checkers and in the flues to remove dirt from system occasionally.

WASTE HEAT BOILERS

Each furnace is equipped with a fire tube design waste heat boiler containing 810 2½-in., outside diameter number 12 gage tubes. The shell of boiler is 10 ft 6 in. wide × 18 ft long. Design pressure is 225 psi, with 475 F total temperature, to conform to steam conditions in the adjacent plant. Each boiler is equipped with a dry steam drum 10 ft 5 in. in length and a diameter of 4 ft 6 in. to insure dry steam. Flues and superheaters are kept clean with 350 psi pressure compressed air operating automatically on a time cycle that usually blows each boiler every eight hours. Feed water is supplied from number one open hearth shop. Each boiler has a panel board containing steam flow and steam temperature recorder, a strip chart recorder on temperature of waste gas in and out of boiler, draft indicators showing draft before boiler, draft before induced draft fan, and draft loss through boiler. In addition, there are steam and feed water pressure gages, and fan control buttons.

INDUCED DRAFT FANS

Each furnace has an induced draft fan after the boiler with a maximum capacity of 225,000 lb per hour of waste gas at inlet conditions of 550 F and total head of 7.25 in. of water gage pressure. Fans are of the double inlet type, and are equipped with multiple louvre type dampers with opposed louvres. Damper positioning is done with a hydraulic cylinder which is part of the furnace pressure control. Motors are 200 hp, two-speed, 440-v, 60-cycle, with a top speed of 720 rpm.

CRANES

Crane equipment consists of the following:

Two 350-ton steel pouring cranes.
One 150-ton hot metal crane.
One 400-ton stripper crane.
Two 12-ton charging machines.
Two 20-ton stock house cranes.
Four 7½-ton jib spout cranes.
Two 15-ton repair trolleys — one for the pouring aisle and one for the furnace aisle.
Four 1-ton capping cranes at the pouring platforms.

Carrier current radio communication is provided in the steel pouring, hot metal, and stripping cranes for communication between cranes and to the floor.

MATERIALS HANDLING SYSTEM

Limestone, ore, dolomite, fluorspar and materials of like nature are handled by a bin system at the south end of stock house running track. Materials are unloaded at ground level into bins that discharge by gravity onto a belt conveyor. This in turn discharges into a skip hoist, which elevates the materials to the top of the building where they are distributed into bins by a belt conveyor. These bins deliver by gravity to charging boxes or other receptacles as desired.

FURNACE CONTROLS AND INSTRUMENTS

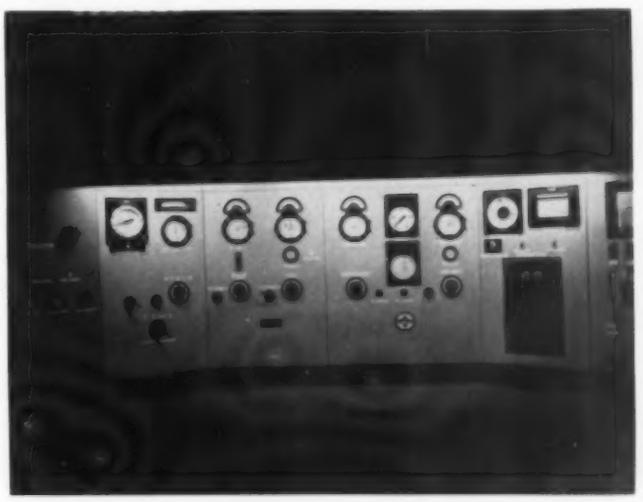
Figure 13 shows the instrument and control panel. The location of the instruments and controls on panel boards, and the angle of panel board wings was determined with a mock setting by a group of melters and first helpers for number 15 furnace in number one shop, and the design was later used in number two shop.

The panel board forms the front wall of the control house and is of sufficient size for convenient field maintenance of instrument panels, control equipment, gages and meters. In another room above each of the panel boards are electrical door and reversing controls.

Instrumentation provided on each panel board consists of roof temperature recorder and controller, furnace pressure recorder and large horizontal dial indicator, air flow recorder-indicator, gas flow recorder-indicator, total Btu recorder-indicator, oil flow recorder and oil flow indicator, steam flow recorder-indicator, checker temperature difference indicator, checker temperature recorder, and numerous gages, lights, and push buttons to facilitate smooth operation.

The controls were laid out with the idea that they should be automatic as far as practical, but so arranged that the operators could at any time easily make

Figure 13 — Back of instrument panel is pressurized.



required adjustments. A furnace pressure regulator of the hydraulic type is provided to operate either the louvres of the induced draft fan or a stack damper by means of a suitable transfer valve. Pressure impulse is taken in front of the longitudinal center of furnace roof.

A fuel summarizer to summarize the total Btu value of oil and gas going to the furnace is provided so that the first helper is required only to set the total fuel requirements and amount of gas he wants to use. The summarizer makes up the difference with fuel oil automatically.

An air flow regulator controls the air flow to the furnace by means of inlet louvres of the forced draft fan and is calibrated 0 to 1,500,000 cfhr. This regulator is designed to hold a constant air flow after being manually set by first helper, but provision was made to convert readily into a fuel-air ratio regulator by the addition of an additional diaphragm system and fuel-air ratio dial.

A steam flow regulator, with a panel board setting dial calibrated to 3500 lb per hour, holds a constant steam flow after being set by first helper.

Oil for the hydraulic controls is provided by two pumps of 20 gpm each located in a central room in middle of shop basement. Instrument and control air compressor is also located in this room along with air compressors for air-operated gates at the bottom of stock bins, and a high pressure air compressor for blowing flues of waste heat boilers.

Reversal of furnaces can be done manually by push button or automatically on time cycle, checker temperature differential, or high checker temperature. The four radiation units for measuring checker temperature on each furnace are mounted so as to sight through the side walls of regenerators and are focused down on the top of checkers near the bridge wall.

Roof temperature controller is a pneumatic type which cuts back the setting on both the gas flow and total Btu controllers simultaneously. Thus, if any gas is on, the gas will be shut off first without affecting the oil flow. After the gas is off, if further reduction is required, oil is reduced by the Btu controller. The roof temperature radiation units sight down on closed end silicon carbide refractory tubes mounted above the tap hole half way between the center of roof and backwall.

Two bath immersion pyrometers with a range of 1600-3200 F and a recorder with chart speed of 2 in. per minute take care of the shop by being mounted between furnaces. The immersion assembly is a Republic Steel development and consists of a platinum rhodium thermocouple protected by fused silica protruding from a carborundum protected steel tube.

MISCELLANEOUS

A departure was made from 25-cycle power in the adjacent plant by the installation of two 11,000-v, 3-phase, 60-cycle supply circuits. Two 1000-kva, 11,000-v/480-v, 3-phase, 60-cycle transformers furnish the 440-v a-c for the shop. Two 1000-kva rectifiers convert 11,000-v, 3-phase, 60-cycle to 250-v, d-c.

Two two hundred ton scales were installed, one at each end of the shop for weighing metal transfer car and ladles at reladling stations. Each furnace has a scale for ladle additions with indicating capacity of 6000 lb × 2 lb.

Completed stopper rods are carried through a drying oven by an overhead conveyor chain located on the ground floor at the north end of pouring aisle.

The dolomite spreader is of the self-propelled diesel engine type running on standard tracks.

A chemical laboratory for preliminaries and finals is located at the south end of the stock house aisle adjacent to the furnace aisle.

OPERATIONS

The foresight and planning that went into the design and construction of this shop is reflected in the tonnage obtained in May, 1953. Production for that month was 70,237 net tons and compares favorably with previous high production of 69,242 net tons made in March of the same year. Fuel practice in May on a gross fuel basis was 3,031,000 Btu per net ton using a combination of 8.5 per cent coke gas and 91.5 per cent fuel oil. The furnaces averaged 23.9 tons per hour. Highest individual monthly furnace production made to date is 18,501 net tons. Steam production on waste heat boilers in May averaged 19,800 lb per hour per boiler.

A hot metal charge of 65.8 per cent was used in May and all steel was poured into 26 × 56 × 90-in. molds. Eighty per cent of product from this shop was cold roll deep drawn quality under 0.08 per cent carbon.

It can be said that results to date are gratifying and have met expectations. For example, in August, 1953 the shop produced 71,783 net tons with 3.8 furnaces at an average rate per furnace of 25.3 tons per hour. New furnace records of 18,855, 19,160 and 19,602 net tons also were made in August.

(EDITOR'S NOTE: Since September, 1953, the time when this paper was presented, some changes have been made in furnace details. Also, additional production records have been set, and the shop has made 75,425 net tons per month. A production rate of 27.9 tons per hr with an individual furnace record of 20,135 net tons per month has been attained.)

DISCUSSION

PRESENTED BY

D. R. LOUGHREY, Staff Industrial Engineer, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

LEONARD LARSON, Chief Engineer, Republic Steel Corp., Cleveland, Ohio.

E. E. McGINLEY, Division Superintendent Open Hearth and Foundry, United States Steel Corp., Munhall, Pa.

E. C. McDONALD, Superintendent, Combustion Dept., Republic Steel Corp., Cleveland, Ohio.

D. R. Loughrey: Mr. McDonald has presented to us a very clear and concise picture of the new No. 2 Open Hearth Shop of Republic Steel Corp. at Cleveland, Ohio. The layout of this shop indicates that it was designed very completely, with all the major units in close proximity to each other, and yet the dimensions which are shown leave the distinct impression that a crowded condition or bottleneck does not exist anywhere. The performance of the shop to date would certainly substantiate this impression.

Beginning with the stockyard, we find it located ideally in a position parallel with and adjacent to the charging floor. Equipped with two cranes and the necessary means for getting the stone, ore, etc. into charging boxes by gravity feed, it should have no trouble supplying the shop.

The furnaces seem to be exceptionally well designed. With their 97-ft length and 22-ft width, they have a length to width ratio of 4.4 to 1. This should produce a good flame coverage of the bath with efficient fuel consumption. The bath area of 1077 sq ft, or about 4 sq ft per ton of capacity is standard and the bath depth of 2 ft 9 in. will permit rapid heat transference.

The 60-in. depth of bottom material is more than sufficient and advantage has been taken of the modern method of ramming the bottom, rather than spending a week burning in magnesite. The only feature which we would question here is the 7½ in. of clay brick used in the flat. In every old bottom which we have dug out, the clay bricks in the flat have been found to have turned to powder, offering no resistance to any bottom boil which penetrated through the basic brick. For this reason, we have confined the use of clay brick to filling in at the corners and front banks.

It is interesting to note that, in view of the general tendency toward heavier roofs, these roofs were lightened after the first run from 18 × 22½ in. to 12 × 18 in. This gives a relatively higher rib, but 12 in. seems rather weak for the low rings in a roof of such long span.

The door sizes are generous, especially in the width dimension and should accommodate the 48-cu ft boxes.

The double uptakes insure rigid end construction with plenty of heating surface and the total area of 119 sq ft will give a gas velocity in the neighborhood of 17 fps, which is normal. The change from straight silica uptakes to the basic veneer will probably pay off handsomely. Use of burner dog houses, sometimes the source of water leakage troubles and heat losses, may protect the burners from warping.

Slag pockets are large and should contain the carry-over material of a campaign easily.

The checker volume of 14,445 cu ft, or 52.5 cu ft per rated ton of capacity is ample, but we would question the division wall in the checkers. This wall does not extend above the checkers and, along with the double flues and four reversing valves, is obviously designed to prevent cross channelling of the gases in the checkers. We have never been able to find evidence of cross channelling with flue type checkers and believe the efficiency of the furnaces would be improved if the dividing walls were replaced with checkerwork. The double flues and reversing valves will not impair the operation of the furnace, but we believe the investment cost does not warrant them.

The system for draining water away from the furnaces is excellent and should prevent any trouble from this source.

Four reversing valves, individually driven, would seem to be a costly installation and might cause back pressure in the furnace if one of the motors failed. We favor reversing arms driven by one 15-hp motor through a gear reducer having a ratio of 37 to 1.

In the fuel burner construction, it is noted that the gas is introduced over the oil. We would question whether the 7 lb available gas pressure is sufficient to insure against the gas rising to the roof on such a long furnace. With this pressure, we would be inclined to put the gas burner under the oil burner.

The combustion fan, delivering 25,000 cfm, would furnish air for burning up to 1000 gal of oil per hour. This should be ample for all purposes.

The instruments and furnace controls are in accord with our thoughts in this matter. Every provision seems to have been taken for the smooth, safe, and efficient operation of the furnaces, without any useless or superficial gadgets. Our one point of difference is in the open instrument panel boards. We installed our panel boards in hermetically sealed houses which are kept under positive air pressure and whose doors are kept locked. This keeps the instruments clean and prevents anyone except authorized personnel from tampering with them. The control knobs and switches are available to the furnace operators on a sloping console located outside the house.

We are very much in favor of the laboratory located on the charging floor. This insures fast service and saves furnace time.

One advantage of a four-furnace shop lies in the fact that heavy auxiliary equipment such as ladle cranes, charging machines, etc., are generally more than ample. Since dependency cannot be placed in one of these machines alone, it is necessary to supply two of each, which gives a much higher ratio per furnace than is possible in a bigger shop.

We wish to congratulate all the people at Republic who are responsible for the very fine production results shown at the conclusion of Mr. McDonald's report. They certainly vindicated the layout and equipment provided for this shop.

Leonard Larson: Prior to and following the decision of our management to proceed with expansion of our open hearth facilities, only a very limited time was afforded for study and layout planning. After preparation of several preliminary skeleton plans, and discussions with our management, operators, and open hearth committee, it was decided to locate the new four-furnace shop adjacent to our present fifteen-furnace shop, with a view of utilizing some of the existing facilities for both shops.

Adequate space, which is difficult to find in the Cuyahoga River Valley, was the first problem encountered. Some relief was provided through cooperation of the City of Cleveland in relocating Independence Road, thereby giving us a slightly wider site, and enabled us to get a slight increase in width of pit and charging aisles.

Differential settlement of foundations as experienced in the old shop prompted careful consideration toward adequate and economic load piles for the new shop. Those of you who are familiar with the Cuyahoga River basin know that sub-soil is very erratic and tricky for sustaining heavy loading. Four Shelby tube borings were taken to a depth of approximately 160 ft, one at each corner of the site. At a depth of 160 ft, we encountered a stiff clay which was considered adequate for our loading, but which would have required pipe piles driven to a depth of approximately 160 ft.

The services of Dr. Terzaghi of Harvard University and Dr. Peck of University of Illinois were employed as consultants in analyzing our foundation problem.

Testing of Shelby tube borings showed that we had a relatively hard clay strata beginning at a depth of 90 ft and continuing to a depth of approximately 110 to 120 ft, with a shearing value capable of sustaining our maximum load concentrations and the overall weight of the superstructures. Four 10-in. pipe test piles were driven to a depth of approximately 100 ft. These piles were tested and failed under loads ranging from 230 to 270 net tons, which was ample assurance that we could develop stable foundations with 100-ft piles, each loaded to approximately 60 tons as limited by City of Cleveland Code.

The question has been raised as to why we installed material handling building and bins for dolomite, limestone and ore at south end of shop instead of the conventional stock house arrangement. This was practically dictated by space limitations, and we hope that it may also prove advantageous from a handling cost standpoint.

The design of our new furnaces is conventional and comparable to several other recent installations in the industry.

It is significant to note that the open hearth of today does not differ materially from that of 50 years ago except for size, improved refractories and refinements in burners, valves and auxiliary equipment. I often wonder how long it will be before someone comes forth with a radical and challenging change in the process.

E. E. McGinley: Certain questions have arisen in my mind as I listened to the paper. The first one was: Has the lack of scrap storage space in the stockhouse resulted in any appreciable operating delays in the charging of furnaces?

Second, what effect on roof life was experienced in changing from heavy roof to the lighter zebra drop section construction?

Third, what has been your experience regarding refractory usage with the higher alumina fire clay brick on the suspended chill box wall?

Four, how well have the suspended fan tail noses and roofs been able to stand furnace shutdowns?

E. C. McDonald: Mr. Loughrey raised the question about gas pressure. We would like at least ten pounds in the open hearth mains in order to increase our burner gas velocity but are limited to seven by the compressor capacity. We have decidedly improved our overall results by introducing the gas over the oil. In answer to another question by Mr. Loughrey about pressurized control houses I neglected to include in my paper that the rear compartment of the control houses is pressurized and we felt this was adequate.

As for design details such as division walls between the checker chambers and the four reversing valves mentioned by Mr. Loughrey, my answer is that these among other design features were the result of many conferences between the personnel of Republic and the builder.

In answer to Mr. McGinley's questions, lack of scrap storage space has not directly caused any charging delays. In fact Republic management expects tonnages approaching 22,000 tons per month from each of these furnaces.

Roof life came close to being doubled after going to the lighter roof. The heavy roof wore excessively along the back wall and the additional weight caused several roofs to fall. High alumina fire clay brick is still satisfactory in the chill box walls. The 15-in. suspended fan tail noses have been replaced on all furnaces with 12-in. brick and now run a furnace campaign. No serious trouble has been experienced with the noses on furnace shutdowns.

E. E. McGinley: Have you had any serious erosion on the fan tail nose?

E. C. McDonald: Yes, and that is largely the reason for replacing them every campaign.

E. E. McGinley: Was the quality of the brick changed?

E. C. McDonald: No, only the length.

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▲THE National Tube Division of the United States Steel Corp. completed an extensive expansion of plant facilities at their Lorain Works approximately three years ago. This mill, located on Lake Erie at Lorain, Ohio, is a fully integrated steel mill, processing iron ore received at its own docks into the plant's primary product—pipe. In fact, the mill has held the distinction for many years of being the largest pipe producing mill in the world. The expansion program of new facilities, begun in the latter part of 1946 and finished in 1950, included dock equipment, additional coke batteries, bessemer converter plant, blooming, bar and continuous rolling mills, seamless mill, and a pipe warehouse. Supplementing these new facilities, a modernization program of existing mills and equipment was concurrently completed. The construction of new facilities in such vast proportions within the existing area of the plant imposed many intra-plant material handling

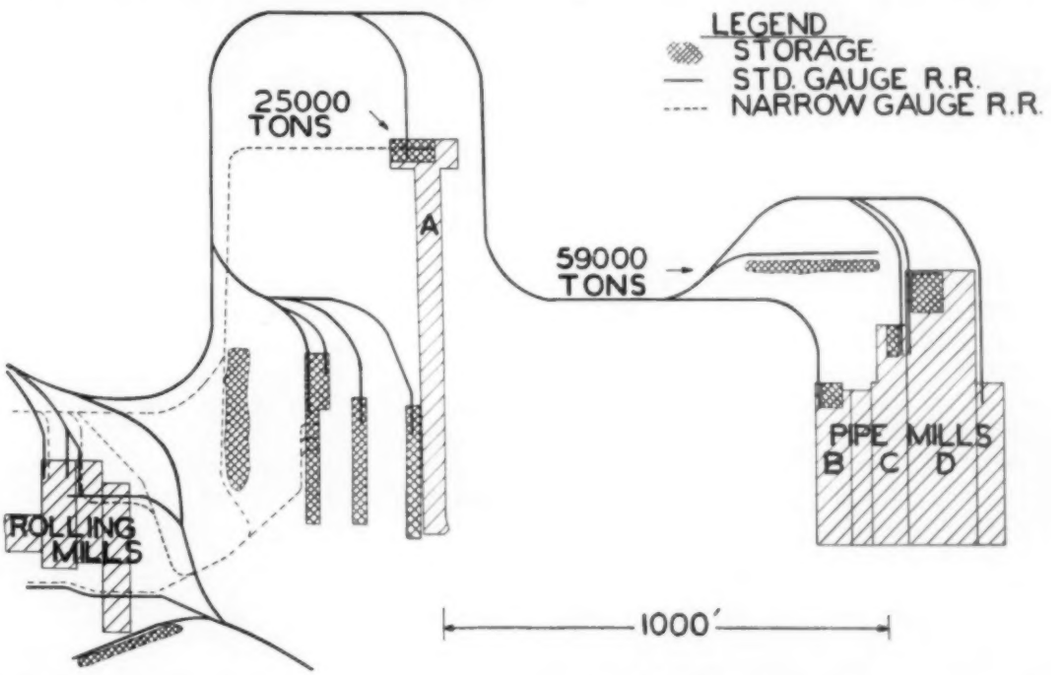

Figure 1 — General layout of the mills primarily involved in the production, distribution and consumption of round billets shows the narrow and standard gage trackage originally provided to transport this material from one mill to another.

problems, which from a production and cost standpoint, became increasingly important as the new mills came into operation.

This paper deals primarily with problems relating to the movement of round billets from the rolling mills to later processing mills and with the intra-plant handling of pipe. It should be pointed out that standard and narrow gage railroads have been the principal means of moving these materials within the plant. Both types of rail service have been modernized with diesel power units, and in the handling problems that are discussed later, the railroads must be considered to be modern facilities in good mechanical condition. Another observation regarding Lorain Works that should be made before discussing the problem of billet and pipe handling is that this plant, unlike many other steel mills, is favored with plenty of room between operating mills.

Figure 2 — Side view shows 45,000-lb capacity straddle truck of the type used to carry billets or pipe.

The selection of equipment in any plant is influenced by many factors, some of which are: the length of the load-haul, tonnage, and dimension or shape of material to be handled. Due to variations in these and other factors, the equipment best suited for one plant could prove to be costly and impractical at another plant.

Figure 1 shows the general layout of the mills primarily involved in the production, distribution and consumption of round billets, and the layout of narrow and standard gage tracks originally intended to handle this product. In addition to the production of round billets, many thousands of tons of square billets and small slabs are also produced and distributed throughout the plant. However, for purposes of simplification, the handling of only round billets for the seamless mills will be considered.

Due to production schedules, mill capacities, and sometimes sluggish movement of material, it was often necessary to stock round billet material in open areas after all overhead crane storage space had been filled. This involved the slow and costly procedure of loading railroad cars, unloading them with locomotive or mobile cranes onto the ground, and then reversing the process when the material was returned.

Several alternative solutions were considered. Additional crane runways could be built in the rolling mill area, rail service could be expanded, seamless mill billet storage rooms could be enlarged. Each of these changes would be very costly and involve a considerable increase in personnel to operate them. A more economical solution appeared to be, in the handling of part of the round billet production off the rolling mills by means of rubber tired equipment, using existing roadways, and storing the material in open fields with a minimum of labor. After the decision was made in 1951 to proceed along these lines, straddle trucks and fork trucks were purchased. As the material to be handled was heavy, only heavy-duty equipment was considered, in fact the heaviest-capacity straddle trucks and the greatest-capacity fork trucks that were available on the market were purchased for this purpose. Figure 2 shows one of the 45,000-pound capacity straddle trucks and Figure 3 shows a 26,000-pound capacity fork truck, both used for handling billets.

With the heavy duty fork and straddle trucks available, the first approach to the problem was to construct a special cooling bed, or skid table, at the discharge end of the mill so that the round billet product could be lifted and handled with the fork truck (Figure 4). This table was ruggedly constructed with inclined 5 x 18 in. slabs set vertically, and although the table has received rough usage from the heavy round billets during the past one and one-half years, it has required practically no maintenance. The fork truck removing the rounds from the skid table can either

Figure 3 — This 26,000-lb capacity fork truck is of the type used to handle round billets. Lift shown on fork truck weighs 13 tons.

Figure 4 — Inclined skid cooling table built at rolling mills permits handling product off mill with fork trucks.

stock the rounds on ground racks in an adjoining area, put them into racks under a near-by crane runway for subsequent surface conditioning, or load them into bolsters for removal from the area by means of straddle trucks. Approximately 480 tons of rounds are handled from the skid table by the fork truck in an eight-hour turn. It should be noted that the only people working in this area are a fork truck driver and a production planning department clerk. No ground crew labor is required to roll the rounds down the inclined rack, to load the rounds into bolsters, or to place them into or remove them from field storage. The production planning clerk keeps a record of the application of material on orders, directs its movement to the proper stock or destination and attaches a manifest to the material for proper identification.

The use of the skid rack, along with the mobile fork and straddle trucks, immediately removed a great restriction on the rolling mill, and delays due to congestion in cooling space, or lack of available narrow gage cars, were immediately reduced.

Storing round billets in an open field with fork and straddle trucks provided an interesting comparison with the old procedure of storing the same material under crane runways. Due to the value and limit to space under overhead cranes, it was necessary to utilize these areas to the utmost, which invariably led to piling one item on top of another. This method of "vertical" stocking is common in many steel mills. Stocking rounds with fork and straddle trucks can be done in a "horizontal" manner, in which every item of inventory is readily available without resorting to digging through or moving other material to get at it.

As experience was gained, the method of storing rounds with this equipment developed in a logical manner. The first attempt at storing rounds on the ground with a fork truck was to lay them in horizontal tiers, separated with 4 x 4 in. lumber. Several ground men were needed to handle the lumber and to nail wedge blocks on the ends of the separator strips. This was soon given up in favor of specially prepared inclined racks (Figure 5) which could be loaded from one end and unloaded from the other end. One ground man was required to strip each row with 2 x 4 in. separators and occasionally help the rounds roll down the incline. This

Figure 5 — With inclined round storage racks, rounds are put onto racks by fork trucks from the elevated end. Each row is separated by 2 x 4-in. lumber. The racks are unloaded from the vertical post end.

Figure 6 — With storage of rounds on flat ground racks, the rounds are put into stock and removed from stock with a fork truck. After removal from the storage racks, the rounds are placed into bolsters for delivery to mills by the straddle truck shown.

Figure 7 — View of rounds stocked in bolsters awaiting delivery to a seamless mill. This storage field is located just outside a seamless mill billet furnace building.

type of rack was also abandoned in favor of a flat ground storage rack (Figure 6) which was cheaper to build and did not require any labor in addition to the fork truck driver. An experienced driver can stock rounds on this type of rack in a compact manner and as neatly as a craneman could lay them down with a magnet. As more fork truck time became required for new jobs, and as more bolsters became available, the stocking of rounds in bolsters instead of on the ground became more desirable (Figure 7). This method of stocking eliminates entirely the intermediate handling of material into and out of ground storage, and makes all items in stock readily available to later processing mills at very short notice.

In addition to removing rounds from the rolling mill cooling beds by fork trucks, many rounds are loaded directly into bolsters by overhead cranes in the round peeling and conditioning buildings. In total there are presently approximately 600 bolsters in service in the rolling mill area, with 200 additional under construction. These bolsters, each capable of carrying about fifteen tons, are used to move material within the rolling mill department, serve as temporary storage racks, or move material to the seamless mills located one-half to one mile away. The services of two to three trucks per turn adequately take care of moving approximately 1,600 tons of rounds per day. Figure 8 illustrates the movements of rounds by straddle trucks. This figure also shows the location of new bolster storage fields in which a stock of rounds is maintained ahead of the consuming mills. Note the storage fields are in the line of travel to the seamless mill so that the same field can be used as a reservoir for empty bolsters, easily accessible for a truck to pick up bolsters on a return trip and deliver them to any location.

This phase of handling material from the rolling mill has developed to a degree that two of the four seamless mills now receive their entire monthly round billet requirements of approximately 30,000 tons by straddle trucks. The remaining two mills also receive a small tonnage of rounds with this equipment, particularly at times when due to close rolling and consuming schedules, the material is needed at the seamless mills within a matter of minutes from the time it is finished at the rolling mill. Although it is not within the scope of this paper to cover detailed transportation costs, it can be stated that the rubber tired method of transportation has proven itself to be economically sound.

In addition to the handling and movement of steel billets by fork and straddle trucks, this equipment has

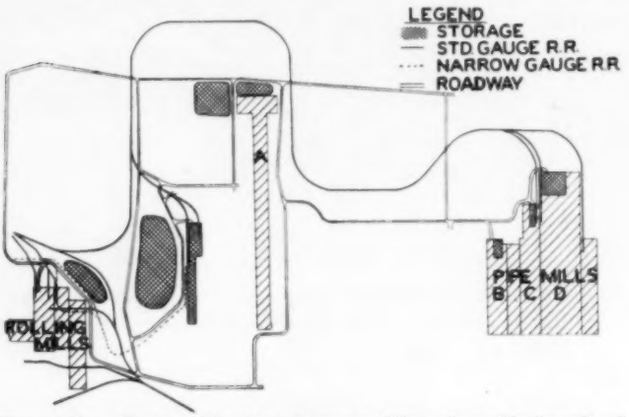

Figure 8 — General layout shows mills primarily involved in the production, distribution, and consumption of round billets, and the roads and storage areas used by straddle trucks to transport and stock this material between mills.

been used to advantage in moving large tonnages of pipe within the plant. The movement of pipe on bolsters with straddle trucks is about as natural an application for this equipment as was the movement of lumber and logs which was responsible for its original development.

In 1947 Lorain completed the construction of a modern pipe warehouse capable of stocking 40,000 tons of small diameter pipe. This warehouse, 1,340 feet long and 125 feet wide, embodies the most modern features

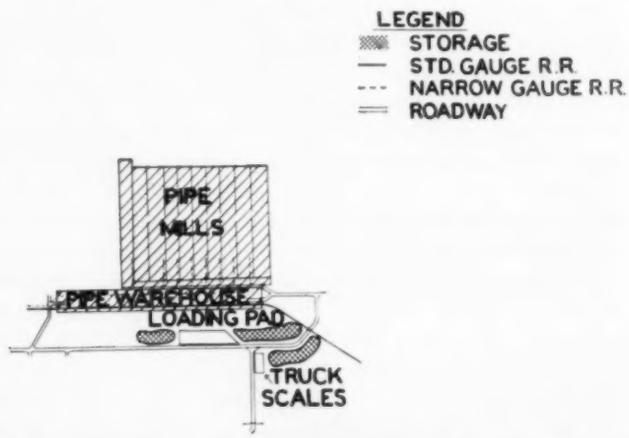

Figure 9 — General layout of pipe warehouse shows standard and narrow gage railroad tracks, roadways, and truck loading pad.

of production line loading. In normal months with three shipping crews per turn, working five days a week, 35,000 tons of pipe are shipped from this building. Although the warehouse was designed primarily for standard gage railroad car loading, provision was made for motor freight shipments from each end of the building. During the past several years, the tonnage of

motor freight shipments has increased greatly. It was soon apparent that if the motor freight trucks could be loaded by fork trucks outside the building, the shipping crews in the warehouse could work uninterrupted on the standard gage car loading line. With this thought in mind, a 90 x 250-ft concrete truck loading pad was constructed in the vicinity of the truck scales just inside the plant gate. Figure 9 shows the general layout of the warehouse with its standard gage railroad tracks and roadways and the outside truck loading pad.

Pipe for motor freight shipment is banded into two to seven ton bales in either the pipe mills or the pipe warehouse. The bales are set on bolsters, picked up by the straddle trucks, and delivered to an outside storage field adjoining the loading pad, to await the motor freight truck arrival. When the truck arrives, it is weighed in at the truck scales and positioned on the loading pad. A straddle truck is dispatched to move the waiting bolsters of pipe onto the pad where a fork truck loads it onto the truck. It is not uncommon for a fork truck to load a truck in six minutes. It can be noted that by making up the truck shipments in advance, they can be fitted into the warehouse operation so there is no delay in loading the standard gage cars in the regular shipping line. Many pipe bales are prepared in the producing mills and moved directly from there by straddle trucks to the outside storage area. In these cases no one in a shipping crew touches the pipe. The cost of shipping labor on this material was reduced sufficiently that the cost of the loading pad was repaid in less than six months. A photograph of outside truck loading operations is shown in Figure 10.

Another natural application for the use of straddle trucks was for the movement of pipe from one seamless mill to another. To illustrate how straddle trucks expedited the delivery of pipe between mills, comparative movements are shown in Figure 11. Note that under the old procedure unfinished pipe was taken from the finishing floor of seamless mill "A" by narrow gage and delivered to an outside crane-line "X" for transfer by a shipping crew to standard gage railroad cars. The standard gage cars were delivered to mill "E" and unloaded by another shipping crew. It was then transferred down a long crane runway "Y" to mill "B" in which it was to be finished. This procedure, patterned to fit existing rail and crane facilities, obviously was costly and slow. Straddle trucks now pick up the pipe from under a crane-line adjoining seamless mill "A" finishing floor, by-pass both the outside crane shipping crew, and the mill "E" unloading crew and carry the pipe

Figure 10 — Outside truck loading operation shows concrete loading pad. Center truck on pad is being loaded by a fork truck.

directly to mill "B" which finishes it. As a result the shipping crew formerly working twenty hours per week in mill "E" was no longer required. Also much of the work of the outside crane shipping crew and the seamless mill transfer cranemen was eliminated. Many other economies resulted—decreased transportation cost, reduced demurrage, and less delay to the finishing unit. A secondary benefit was in the flexibility of stocking unfinished pipe in bolsters, where any particular size or grade was readily available on request.

After straddle truck movement of pipe from the warehouse or pipe mills to the truck loading pad and from one pipe mill to another became an established procedure, and the economy in moving material in this fashion became more obvious, other applications for this type of transportation followed. The limit to the amount of work that could be done was determined by the number of trucks available.

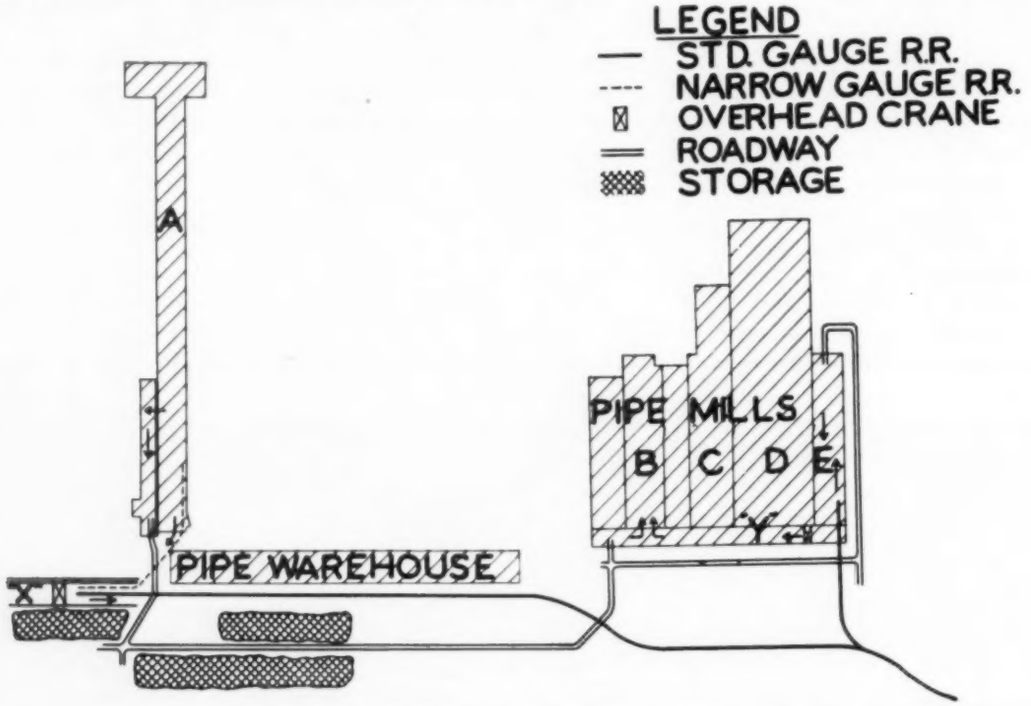

Figure 11—Sketch shows original and present means of transporting pipe from seamless mill "A" to seamless mill "B." Pipe was originally moved by narrow gage railroad from mill "A" to crane "X," transferred to standard gage cars and moved to mill "E," moved down crane-line "Y" to mill "B." Pipe is now loaded on bolsters in mill "A" and transported by straddle truck directly to mill "B."

An interesting use of straddle trucks in the pipe mill area was for the movement of pipe to make up "mixed" car shipments. Many carload orders call for part butt-weld and part seamless pipe. These two classes of material are stocked about three-fourths of a mile apart. It has long been the established practice to start a carload in one area, pay a railroad switching charge on the car and complete the load in the area in which the major part of the pipe shipment is stocked. As the smaller part of the "mixed" load is usually less than fifteen tons, it is very economical to load this portion into a bolster, transport it (in a very few minutes) to the shipping area containing the major portion. Although transportation economy prompted the use of straddle trucks for this work, secondary benefits were experienced in faster movement, less reloading of cars due to pipe shifting, and reduced car demurrage. A similar type of problem which involved the movement of butt-weld and seamless finished pipe for galvanizing was resolved by using straddle trucks. Again, this material was normally loaded into gondola cars. Although reduced transportation costs justified the movement by straddle trucks, the most important benefits were obtained from being able to stock this pipe in bolsters ahead of the galvanize department. Lack of storage facilities in this area in the past resulted in the pipe remaining too long in gondola cars accumulating demurrage. To keep demurrage charges as low as possible, it was the practice to stock the seamless pipe under an outside overhead crane-line ("X"), and hold the pipe there until it was scheduled to be galvanized. After it became the practice to stock the seamless pipe in bolsters, the last remaining reason for maintaining a shipping crew under the outside crane was removed and the outside crane yard "X" was abandoned as a shipping point.

At the present time the handling of all long length scrap from the pipe mills is being undertaken by straddle trucks. It was formerly the practice to move this material from each mill to the scrap shears located in one of the seamless mills by means of mill cranes or from outlying mills by means of standard gage cars. To gain economy in the accumulation and preparation of all scrap from the entire plant, a scrap shearing and preparation area was established at a central plant location. The scrap is now loaded onto bolsters and quickly moved to this area from any individual mill. This procedure eliminates the necessity for scrap to flow counter to the normal movement of finished pipe and avoids congestion of overhead cranes and delays to mill operations.

All intra-plant movement of pipe for maintenance use is handled by straddle trucks. The pipe can be put on a job location much easier and quicker than it can be done by railroad car movement, and cheaper than it can be done with truck and trailer.

When straddle trucks were first considered for Lorain, two possible limitations were of concern; the first

was the temperature of the material that could be handled, and the second was the performance of the equipment during the winter months. The first is definitely a factor that must be considered, and for reasons of safety, a 600 F maximum temperature has been set for material handled. Measuring sticks for this temperature are available to all drivers if a question of temperature arises. Safety alone should dictate this practice, although tire life would suffer considerably if excessively hot materials were carried. The second factor, namely equipment performance in winter weather, has not proved to be a major concern. The large truck wheels with military tread tires (14.00 x 20) keep the equipment moving when other rubber tired equipment bogs down. It must be remembered that straddle trucks can jack themselves up with their own hydraulically operated lift arms and can get themselves out of almost any rut or depression. Three years of winter operations have proven the year-round performance of this equipment.

It would be impractical to set up a fleet of fork and straddle trucks in a steel mill to handle the heavy materials produced there without giving a great deal of attention to the maintenance of the equipment. Experience has shown that one of the most important factors controlling maintenance costs is driver experience. Four wheel steering, clearance of tires, wheel shields, lift arms, extended loads and height of lifts, all serve to confuse the new driver. Time spent in training new drivers is abundantly returned in the form of reduced tire breaks, less dented shields and less actual damage to the frame or hydraulic system. The problem of driver inexperience is compounded if he starts to work in winter, where snow or ice will sometimes skid a truck sideways as it comes in over a load. Trucks are maintained at Lorain in a modern four-bay garage, equipped with overhead hoists and manned by competent personnel for sixteen hours per day. Although experience has indicated which parts are critically needed for routine repairs, a full complement of spare parts is carried to hold truck outage time to a minimum. One complete motor is carried as a spare for the entire fleet. The replaced motor is repaired or overhauled and held for the next replacement.

It has been found that after about two years of continued (three turns per day) operation, the trucks require more than normal maintenance and it has been the practice to overhaul them completely at this time. This service time represents approximately 14,000 operating hours. Since the oldest truck in service operated two years, then was overhauled and has operated one year since, we cannot give a final opinion concerning the total life of the equipment under the conditions worked at Lorain. It can be said, however, that this truck is performing satisfactorily at present with no more than normal maintenance.

Bolster maintenance is also a problem of importance. At the present time there are approximately 1100 bolsters in use within the plant. Approximately thirty to forty bolsters require straightening and rewelding each month. Although the cost is not excessive considering the number used, the repair of bolsters must be set up as a systematic procedure in order to keep too many from going out of service (or onto the scrap pile). Bolsters are relatively expensive, and a considerable investment is tied up in them. It is therefore important that this value be respected by drivers, mill personnel, and welding repairmen.

Aside from the actual maintenance of the equipment itself, it is important to give consideration to the condition of the roadway and field storage areas. There appears to be no question that these factors are definitely associated with equipment maintenance costs. Although it has been pointed out that straddle trucks can "lift" their way out of almost any road or field rut, this by no means justifies the neglect of these areas. Although desirable from a riding comfort standpoint, it is not necessary to embark on an expensive concrete road building program as soon as a few straddle or fork trucks are purchased. Smooth surfaced roads and fields are important but these can be obtained by proper drainage, making a base with coarse slag or stone and choking off the coarse material with fine slag or stone. Repeated gradings and use will establish a hard-packed surface that will require little upkeep. Money spent in proper drainage can be more than saved in eliminating the necessity for concreting many feet of roadways or large storage areas. For areas on which a fork truck operates to load bolsters or motor freight trucks it is desirable to have a good smooth concrete surface. This is to enable the driver to make rapid accurate moves and have good control when "inching" his forks into position.

All straddle and fork trucks at Lorain are equipped with two-way radio receivers and transmitters. A radio dispatcher directs the movements of all trucks from a central radio transmitting station. It has been found that greater efficiency and truck utilization can be obtained by "pooling" all the equipment under the dispatcher's direction rather than by assigning them to a particular job or mill. With this procedure all requests for material movement are called to the dispatcher by telephone and he in turn assigns the tasks to the trucks best able to handle them. It is thereby possible to concentrate the truck equipment where it is most needed and minimizes "standby" time in a particular area. With radio direction it is possible for a truck to pick up many two-way loads which would be impossible if the trucks were working on a ticket-dispatch basis. The radio equipment has worked very satisfactorily. Considering the continual use and vibration it receives, it is amazing how little maintenance is required. It might be mentioned that the narrow gage locomotive and police cruising cars in the plant have radios that can be contacted from the same central transmitter.

As an aid to truck drivers, all trucks were originally equipped with supersonic sound actuated mill door openers, and have since been converted to radio-actuated door openers. Both systems were effective in getting the heavy mill doors opened without delaying the truck movement; however, it has been the mill's experience that the radio-actuated device is easier to maintain and less expensive to install. With the radio door opener, the driver merely presses the transmitter button on his radio mouthpiece as he approaches the door and the one-tube receiver connected to the door

motor will start the door in motion. After he has cleared the door, another press on the button will start the door down.

Each truck is also equipped with a motion recorder. This clock and recorder will give a graphic picture of the truck movement over the twenty-four hour work day. Analysis of these charts indicates idle periods which are studied for maintenance delays, poor truck scheduling, or too much "personal" time. It might be said that the recorders were not popular at first with the drivers, however, they are now accepted as part of the job.

In total, eight straddle trucks and three fork trucks are operated at Lorain to handle pipe and billets. Of the eight straddle trucks, six are scheduled to operate twenty-four hours a day, one other truck serves as a spare to fill in for maintenance outages or lubrication, and the eighth truck is available for overhauling. Of the three fork trucks, two are operated continuously, the third operates on day-turn and serves as a spare on the other two turns.

Handling material with fork and straddle trucks inside the Lorain Plant has grown rapidly in the past two years. It has been the practice to take on additional work for this equipment only after the previous problem has been worked out to a state of practicability. The trucks are in great demand for moving all types of material, and care must be used so as not to extend their coverage beyond the capacity of the limited number of trucks available to handle the work. In a plant of this type, requiring the movement of heavy material for relatively long distances between mills, and having large open areas available for outside stocking, the possibilities for the use of this type of handling equipment is almost unlimited.

DISCUSSION

PRESENTED BY

L. R. ASTIE, Assistant General Foreman, Maintenance, Labor, Riggers, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

HENRY VEITH, Project Engineer, Design Engineering Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

P. L. TIETJEN, Manager, Traffic and Transportation Div., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

E. HALL JONES, Chief Shipper, Republic Steel Corp., Canton, Ohio.

JAMES D. SCANLON, JR., General Foreman, Carrier Operations, United States Steel Corp., Duquesne, Pa.

FREEMAN H. DYKE, Vice President and General Manager, United States Metals Refining Co., Carteret, N. J.

J. D. TYSON, Superintendent, Warehousing and Shipping Dept., National Tube Div., United States Steel Corp., Lorain, Ohio.

Russel Astie: I believe Mr. Tyson stressed that a lot of room is required to operate straddle trucks. We at Pittsburgh Works felt that way about fork trucks for a good many years. We felt that we could not use them because we had an old plant and we did not have the room to use them. We did not have paved roadways such as were found in other plants. We would go and admire their operations, and then wished that we could adopt the same methods. We finally got started in paving our yard areas. Today we have paved yard areas, ramps, and roadways that enable us to palletize to a very large degree.

We do very little manual lifting in the movement of materials. I believe that if any man around the plant has to carry more than 15 pounds in weight, he will yell for a fork truck. Also, I believe that, before long we will do the same thing with respect to adopting the use of straddle trucks.

Henry Veith: The first thing that I was impressed with was the fact that Lorain has acres of ground around that plant. That seems to me to be an essential item in the operation of this type of equipment. I would be interested in hearing how this type of equipment would adapt itself to a very closely adjusted plant. I was also impressed by the operation and moving of this equipment and material. The way I see the operation, it consists of picking up the material with a fork truck and setting it in a bolster and then later on coming along with a straddle truck and picking it up and moving it somewhere else. It seems to me that there is some excess handling there. Why is the operation not done with the fork tractor all the way? I would like to hear that explained.

I would like to ask the author if there was any study made on the stocking efficiency of this type of equipment as compared to the conventional ways? I would also like to ask the writer if they have incurred any increase in accidents, especially to personnel due to the use of and the higher concentration of mobile equipment in the plant?

Another thing that occurred to me would there be any resistance of the operating people to this type of equipment, especially in production operations?

P. L. Tietjen: Is the equipment gasoline power driven or diesel power, and what are the advantages?

E. Hall Jones: We would like to relate briefly our experience with the development of the use of straddle trucks in Canton, Ohio Steel Division of the Republic Steel Corp.

Our problem was dissimilar to Mr. Tyson's in this respect—it was to supplement existing means of intraplant transportation (standard gage and narrow gage) to accommodate increased melting, blooming and bar mill rolling capacities and expanded heat treating and bar finishing operations.

For the reason that hard surface roadways existed and large open areas were available adjacent or enroute to our processing operations, the use of straddle trucks was developed in 1947.

A type of bolster was developed which could be used generally and accommodate any section or length of material. The result is that presently our bar mills and subsequent processing operations are serviced almost entirely by means of the straddle truck, without which we could not have hoped to attain the peaks of production that have been reached, without expending

huge sums of money for increased rail transportation facilities (locomotives, cars, etc.) buildings, crane runways and handling labor.

We are now conducting a study preparatory to the development of the use of lift trucks in conjunction with the use of straddle trucks in performing our truck and car loading operations.

For this reason, we expect to benefit greatly by Mr. Tyson's experience at the National Tube Division—United States Steel Corp. In that, I would like to ask a question.

Is it necessary to take into consideration some standardization with respect to the size of the lifting or the length in loading trucks with the lift truck?

J. D. Scanlon: I would like to make a few remarks concerning the question of operating space necessary to successfully carry on a straddle carrier operation.

Duquesne Works was built around the turn of the century and, as with most steel plants erected around that time, it has expanded in an attempt to keep up with modern developments. This expansion took place in the space available after the plant was originally laid out and as a consequence advance planning could not be done. Duquesne Works therefore has only a limited amount of space to carry on the straddle carrier operation. In spite of this limited space, however, Duquesne Works now has, after a year of operation, four units operating 24 hours a day, seven days a week, with one spare unit. With these four units and using one spare, we now service five widely-spread conditioning yards and we completely stock and deliver the steel billets which are necessary to operate two bar finishing mills, each of which averages 20,000 tons of production per month.

The space that we needed for this storage operation was gained by grading and filling fields that were previously unusable; by vertically piling materials, such as lumber, with fork-lift trucks; and by the use of storage space previously used by a past method.

At Duquesne Works we operate as a material handling department, and, in addition to handling billets for our production units, we also supply the fork truck and straddle carrier service for the entire plant. We handle such items as bloom-down ingots, lumber, brick, spare parts, and scrap. We handle material that ranges in size from 1½ inches in cross section and 30 feet in length to material that is 6 feet long and 16 by 20½ inches in cross section. To handle our needs, some 6,000 bolsters are in use. We have used wood primarily in the making of our bolsters and they cost us approximately $18 each. Our breakage averages ten bolsters per month but we can repair them at a nominal cost. Slow-moving product is removed from bolsters and piled by fork-lift tractor to keep the number of bolsters to a minimum. Our entire operation is controlled by a centralized dispatcher through the use of a two-way radio system which has proved very advantageous to our operation.

In answer to one of the questions which was asked previously, a fork truck, which is used for vertical piling, must necessarily be a low-geared, slow-moving vehicle. A straddle carrier is capable of traveling approximately 35 miles per hour carrying loads of 15 to 20 tons. It is therefore much more advantageous to move material by carriers rather than by fork-lift tractor if it is necessary to transport it for any distance.

In addition to the benefits which Mr. Tyson mentioned in his paper, I should also like to state that in our straddle carrier operation at Duquesne Works we have assisted our good housekeeping and safety program by storing spare parts in our bolster yards. This feature allows us to keep cleaner operating floors and yet insures quick delivery of the spare parts in case of a breakdown. We have been able to provide quicker movements of semi-finished material for our production units, which assists our plant in keeping order-promise dates and helps to provide better customer satisfaction. Our program has also helped us to more fully utilize valuable overhead crane space by storing material in open fields. We have also been able to obtain the flexibility that is needed to eliminate the congestion which might occur in any unit.

I would like to ask the speaker if he uses a centralized department or whether his system is controlled only by a dispatcher, I would like to inquire if the speaker believes that 600 F is the maximum temperature of material which he would recommend be carried by a straddle carrier.

Freeman H. Dyke: Mr. Tyson has presented a paper which is most instructive and timely. After spending most of my life in the steel business I am now producing copper. The problems are more or less the same. If you apply the following definition to material handling you will find that it causes about the largest increment in your labor costs.

"Material handling is any movement which does not change either the physical form or the chemical composition of the material handled."

By the proper application of this definition the putting of a blank into a press and the removal of the finished piece is material handling.

Some people have commented that they do not have room to use industrial trucks. Consequently they are apt to work in a state of perpetual confusion. Possibly they can obtain an answer by an economic study of the following.

Building area under a crane is worth	$_____sq. ft.
Area under outside crane runway is worth	$_____sq. ft.
Paved vacant area is worth	$_____sq. ft.

If the above factors are given the proper consideration you may find a relatively small expenditure will solve your problem, eliminate congestion and speed up your daily operation.

The Timken Roller Bearing Co. at Canton, Ohio, has done more along this line than any other heavy industry with which I am acquainted.

In a recent issue of the Iron and Steel Daily News a travelloader was advertised. I purchased one last year for handling long lengths such as pipe, it is more adaptable than a fork truck.

Such a tool also cuts down the width of aisles, which question was raised by other comments on this paper.

I would like to make one general statement about types of equipment. Our experience has shown that a

truck designed for fifteen ton loads will have a lower operating cost per hour than one designed for ten ton loads.

J. D. Tyson: The author is appreciative of the comments and questions presented by the six discussers who represent such a varied field in materials handling. Their contributions unquestionably add to the scope of the paper and supplement several points which may have been under-emphasized in the original text. Since similar questions have been raised, and to avoid duplication the author will attempt to answer all questions without referring to their originator.

A question that was asked by several referred to the necessity for a wide-spread plant with ample roads and storage fields to satisfactorily and economically use straddle trucks. This question cannot be disposed of with a general answer. Up to certain limits, space is unquestionably an advantage in planning bolster storage areas; good roads unquestionably relate to decrease equipment maintenance and assist in more rapid delivery; non-congested mill layouts undoubtedly provide flexibility in equipment movement. It cannot be said that if all the conditions are not available the principles described are impractical. It is a well established fact that straddle truck transportation is economical in several rather confined mills as is attested the discussion regarding Duquesne Works of the U. S. Steel Corp. To provide an answer to this question the conditions of the individual plant must be studied with regard to its physical layout; its present transportation costs, if it is a problem of substitution; comparative capital investments and operating costs, if it is a problem of facility expansion. In addition to the solution of operating problems, the studies should resolve questions concerning engineering, industrial engineering, accounting, and industrial relations. There is no quick answer to the question of equipment adaptability without studying the problem thoroughly for the individual mill involved.

The question of safety was raised by several discussers. Because of the large wheels (46 in. high), the overall width of the truck (9 ft), and the operation of this equipment in confined quarters, it is natural to assume that it should present considerable hazard. It has been our experience that sometimes the more hazardous operations have the better safety record because the hazard is well recognized. During the three years, straddle trucks have operated in our plant there has been no accident involving a straddle truck and a pedestrian, nor has there been an accident between a straddle truck and a moving vehicle on a roadway. Also with regard to safety, the question was asked if we consider that 600 F is the maximum safe temperature of material that can be handled. We know that other plants are handling material at higher temperatures with apparent safety by shielding the underside of the truck and tires. In our case the flow of material is not restricted by allowing it to cool to below 600 F before moving it. While this temperature has been arbitrarily picked we feel that it is to our advantage to work with as low a maximum temperature as possible, consistant with unrestricted material flow, in order to improve tire life, preserve truck grease lubrication and reduce to a minimum the danger resulting from a broken fuel or hydraulic oil line.

The author was asked if it is necessary to take into consideration some standardization with respect to the size of the lifting or length of the load in loading trucks with a fork truck. Fork and straddle truck capacities, mill crane capacities, state highway load limits or restrictions, as well as customers' handling facilities all have an influence in determining the size and length of load handled. Although it varies with individual cases, it can generally be said that the weight of bale loaded by fork trucks onto motor freight carriers has become standardized around three-seven tons. Three such bales are usually loaded on a motor freight flat bed two wheel semi-trailer. The major part of the pipe tonnage loaded on trucks by fork trucks is approximately 21 ft long.

Several miscellaneous questions can be answered briefly. The straddle truck equipment operated at Lorain is gasoline powered. Similar trucks have recently been made available with diesel power and it would be well for anyone considering the purchase of this type of equipment to study the advantages of each.

The growth of rubber tired transportation along with plant production expansion has occurred with very few industrial relations problems. Observation of the equipment in action gives an immediate impression of improved efficiency and performance and serves as the most convincing season to operating personnel for its installation.

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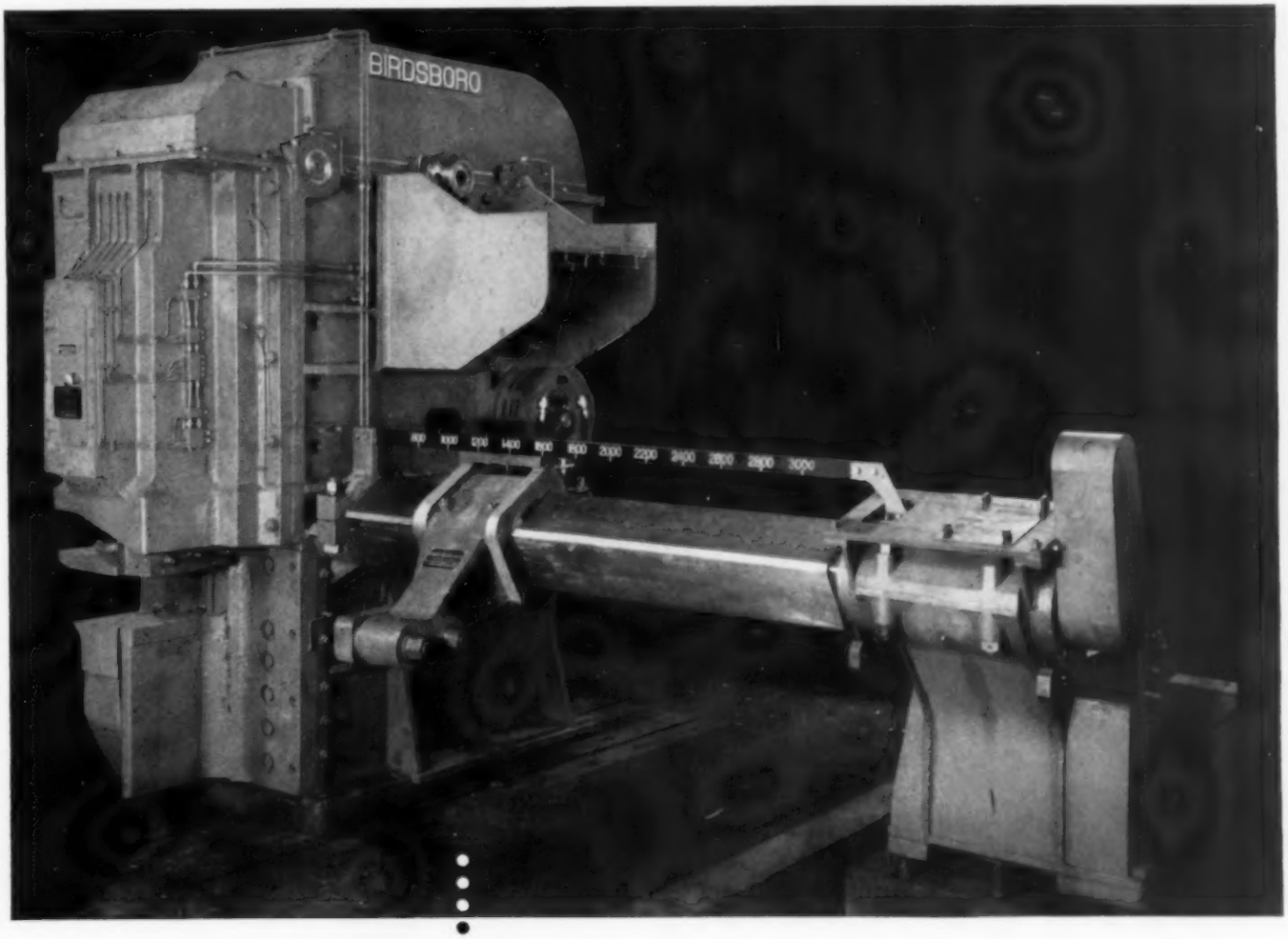

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ALCOA STARTS OPERATION ON GIANT EXTRUSION PRESS

▲ THE world's largest press (Figure 1) for the extrusion of metal has begun squeezing out giant aircraft parts at Aluminum Co. of America's Lafayette (Ind.) Works. The operation of the 14,000-ton press signals the productive beginning of the multi-million dollar U. S. Air Force Heavy Press Program. Giant, extruded aluminum shapes from this unit are the first of the light, strong, low-cost aircraft parts to come from the big extrusion and forging presses leased to industry under this program.

These presses will produce vital aircraft components. Parts produced by these big presses will substitute for aircraft sections that formerly had to be assembled from many small components. The products of the big presses not only will afford large savings in cost, but also will contribute to a revolution in aircraft design.

The press at Alcoa's plant has a long history. It was originally intended for Hitler's War Machine and was being constructed by Schloemann, A. G., Dusseldorf, Germany. At the end of World War II, it was practically completed. The United States government placed an order with Schloemann for the work to be finished and the press was purchased for shipment to this country.

Under the direction of Alcoa engineers, the press was re-designed to meet American production standards and its capacity enlarged from 13,200 to 14,000-tons. A sister press of 13,200 tons had already been taken behind the iron curtain by Russia.

Alcoa can now offer extrusions weighing as much as 2500 lb and measuring as long as 110 ft per piece. The size that can be produced in that length has increased with the operation of the 14,000-ton press from 5.4 lb per foot to 22.7 lb per foot, or from 4.5 sq in. in cross-sectional area to 19 sq in. The practical maximum circumscribing circle diameter for shapes has increased from the present 13 in. to 23 in. Because of the high unit pressures that the big press can exert on strong aluminum alloys, Alcoa can offer extruded shapes that are not only larger and longer but also thinner than previously possible. This results in a highly desirable combination of light weight and high strength. For example, aluminum pipe up to 20 in. in diameter can be extruded on the press.

Alcoa's part in the Heavy Press Program also includes a mammoth new forging plant at its Cleveland (Ohio) Works. Work has begun there on the installation of 50,000-ton and 35,000-ton vertical forging presses, two of the world's largest hydraulic forging presses.

The press is installed at Lafayette as the key element of a highly integrated production unit. While the giant presses of the Air Force program attract the public and industrial eye, they would be helpless without complex auxiliary equipment. Such is the case at Lafayette where auxiliary units are as impressive as the press with which they are integrated.

Alcoa has provided a 3,000,000-lb capacity, 180-ft long stretcher to relieve stresses and straighten the extrusions and a 120-ft horizontal heat-treating furnace that will improve mechanical properties of the extruded shapes. These are only part of the equipment necessary to help the big press produce.

Ingot heating — The first production operation on extrusions from the press involves heating the cast extrusion ingots in 60-cycle induction coils. Sufficient induction heaters are used so that heated ingots are at temperature when needed. These heating units were designed and built by Alcoa (the company perfected low cycle induction heating during the past few years). Coils are provided for each ingot diameter and the units are so designed that coils can be changed with ease and rapidity.

Ingot handling — The extrusion ingots are fed to the induction heaters and then to the press. Ingots are loaded directly into the press with a muzzle loading device that places them in the press between the cylinder and the platen. As the cylinder is advanced toward the platen, it slides over the ingot.

The cylinder length of the press is 79 in. and the stroke of the press is approximately 90 in. The 79-in. length of cylinder permits the use of an ingot having a maximum length of 72 in. Cylinder bores of 15¼, 18¼, 21¼, 25¼ and 29¼ inches have been provided to handle the different diameters of ingot to be extruded. See Figure 2. A cylinder bore of 15¼ inches permits the use of about 153,000 psi unit pressure on a dummy block. On the other hand, the 25¼-in. bore affords a pressure of only 56,000

Figure 1 — Over-all view of world's largest extrusion press. This 14,000-ton unit has just begun full production at the Lafayette, Ind. works of Aluminum Co. of America.

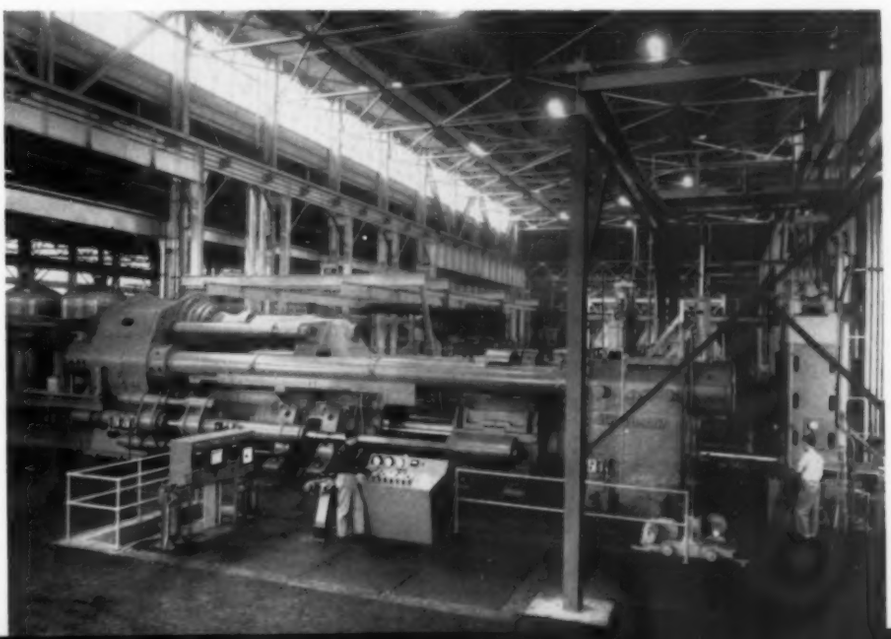

Figure 2 — The big extrusion cylinders shown are the metal container assemblies for the 14,000-ton aluminum extrusion press. These big assemblies, which weigh as much as 57 tons each, are used to hold the extrusion ingot. The press ram then pushes through the assembly and extrudes the metal through the die at the other end. A different assembly is required for each different diameter of extrusion ingot.

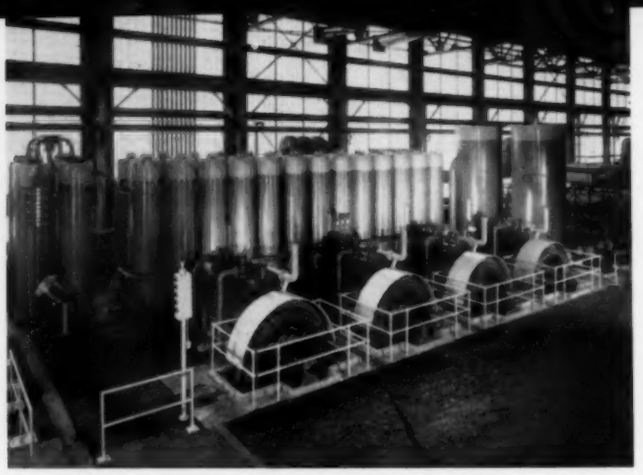

Figure 3 — The hydraulic system for the 14,000-ton extrusion press has 30 bottles and two storage tanks. The four bottles on the extreme left are the water bottles; and two water storage tanks are shown at the extreme right. All the remaining cylinders are air bottles.

psi on the dummy block. Past experience has proved conclusively that relatively high unit pressures are necessary for the production of large, long, thin webbed, strong, aluminum alloy extrusions. The cylinder bore of 29¼ inches is maintained for use primarily for the production of tubular products.

The tool container on the 14,000-ton press can be moved hydraulically from the cylinder sealed position to the butt shear position. This places the tools in position for servicing between charges. The distance from the cylinder to the butt shear position is 17½ ft.

Press design — The press itself is a three-ram, four-column design. The columns are of forged steel, 25.59 in. in diam and 57.4 ft long. They are arranged in a square pattern on 118-in. centers. This arrangement permits removal of the cylinder container by lifting up between the two top columns.

The three rams are arranged on the vertical center line of the press, and are connected to the working ram through a yoke and cross-head arrangement. Two of the rams are of 2850-ton capacity each and one ram, the center ram, is of 8300-ton capacity.

The press can be operated as a 5700-ton, 8300-ton, or 14,000-ton capacity unit. The principal advantage for operating the press at lower than maximum capacity is to utilize the tools that cannot be built with enough strength to withstand the total effort of the press. In the production of certain intricate shapes, such tools are sometimes necessary.

The press is equipped with a mandrel manipulator for tube production in lieu of the more usual piercing ram. The stroke of the manipulator is 51 in. which is sufficient to produce finished lengths of 50-ft of 20-in. diam tube with 0.250-in. wall.

Tool heating — Tool heating for the press is accomplished by means of low frequency induction coils. Three water cooled, induction coils are provided to heat the die-assemblies. Each coil is capable of heating a tool up to 50 in. in diameter by 28 in. thick.

A large gas-fired holding furnace with three compartments is used for holding tools in readiness after induction heating. It is well known that preparing a die to produce satisfactory dimensions and surface in the extruded product is an art. Press trials are customary to be certain that the die will produce a product of the highest quality. The gas-fired holding furnace is employed to insure the maintenance of press tools within close temperature limits.

Hydraulic system — The pressure system for the press is a hydro-pneumatic-accumulator. This accumulator system consists of 26 air-bottles, four water bottles and two water storage tanks. A system pressure of 4500 psi is maintained by 4 water pumps capable of delivering a total of about 916 gpm.

In Figure 3 which shows the accumulator system, the four bottles at the left are the water bottles, and the two water storage tanks are shown at the right. All the remaining cylinders are air bottles.

A 100-ton overhead crane was provided in the 14,000-ton press bay in order to facilitate maintenance of the press. Two of the castings in the press actually weigh slightly over 100 tons each.

Maintenance facilities for large tools are also planned, but these have not yet been installed. A large turning and boring lathe and also a large horizontal boring machine will be installed adjacent to the press.

Heattreating — Solution heat-treating of material produced from the 14,000-ton press is generally accomplished in the 120-ft horizontal furnace. This big furnace is equipped with a conveyor hearth and has forced, vertical, downward, air circulation. It is a gas fired, batch type heating furnace. Quenching is performed by continuous travel on a roller conveyor through a spray chamber.

Spray quenching of large extruded shapes as used here is advantageous, as compared to immersion quenching, in securing a high rate of quenching since it shortens stage A and stage C cooling. These are the vapor blanket and liquid cooling stages, respectively.

Vertical electric furnaces arranged for rapid immersion quenching are employed for extrusions up to 40 feet in length.

Stretcher — After solution heat treatments, the big extrusions from the 14,000 ton press are stretched to relieve internal strains which sometimes occur in extruded shapes that are designed with elements of differing thicknesses. For this job Alcoa has installed the giant 3,000,000-pound capacity hydraulic stretcher.

The machine is capable of stretching a 120-ft length of 75S extruded

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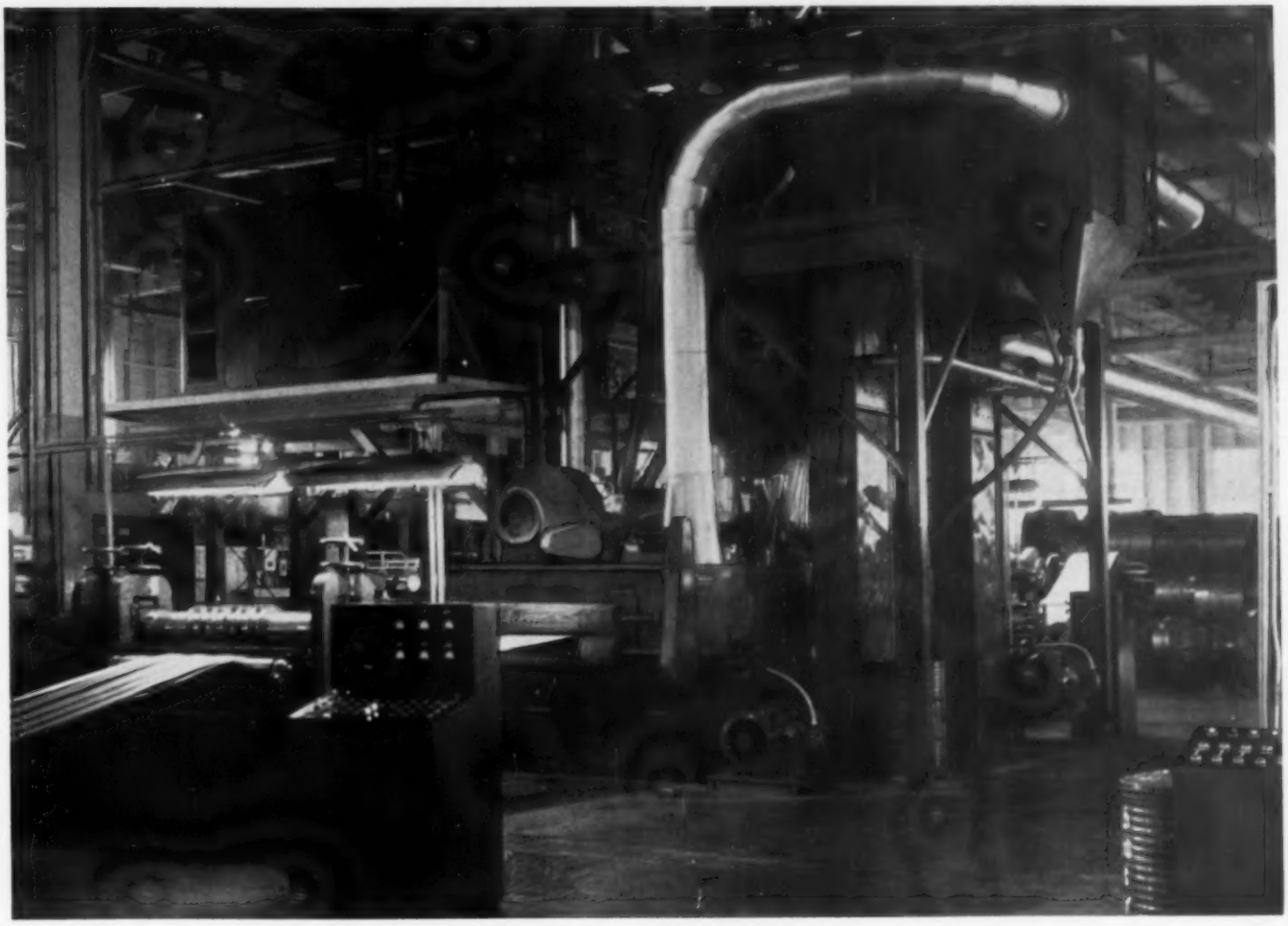

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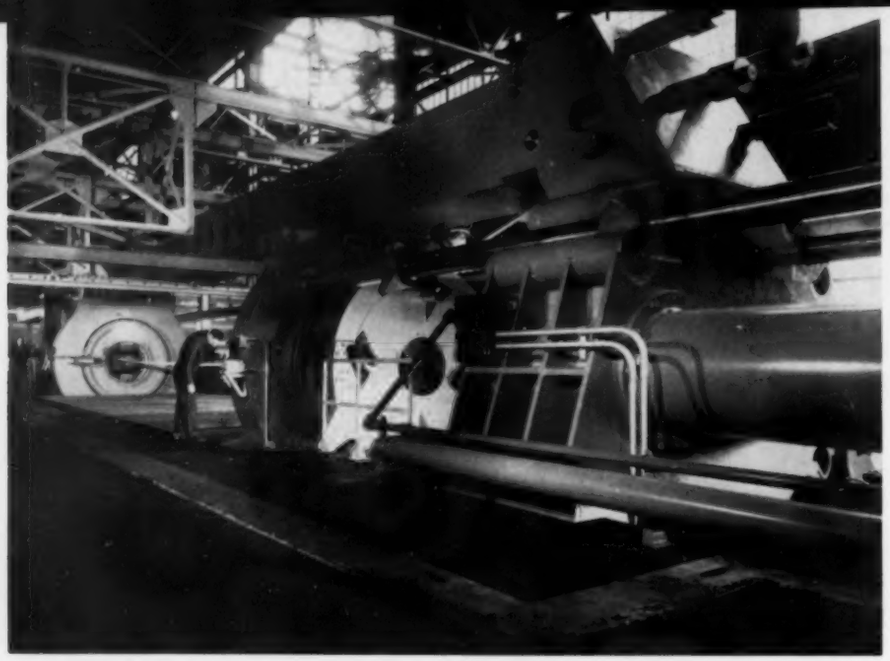

Figure 4 — The three million-pound stretcher shown is used to "pull" extrusions produced on the extrusion press.

shape with a cross sectional area as large as 60 sq in. The maximum width of the shape that the stretcher can accommodate is 37 in.

The big stretcher, which can be seen in Figure 4 is 180 feet long overall. The stretcher heads are mounted on two big box beams which are 130 feet long and each weighs approximately 123 tons. One of these beams can be seen in the photograph, and the other is located beneath the floor level.

Extra safety allowances had to be built into the stretcher, for if an aluminum alloy extrusion should break under maximum tension there would be the instantaneous release of as much as 17,000,000 inch pounds of kinetic energy. Were means not provided within the machine itself to dissipate this energy it can be shown theoretically that the broken pieces might be propelled as fast as 100 miles per hour.

Finishing — Finish sawing of the extruded shapes is accomplished on a 96-in. saw which is capable of sawing any extruded shape that can be circumscribed by a 33-in. circle.

A 120-ft direct gas-fired batch type aging oven is used for artificially aging long lengths produced from the press.

Additional finishing equipment, such as roll contouring machines and untwisters are used in finishing extrusions from the press.

TABLE I

Manufacturing Limits for 5200 Ton, Smaller Presses and the 14,000 Ton Press (Average Extrusions)

5200-Ton and Smaller Presses

Circumscribing circle size, in.	*Minimum thickness, in.			
	61S-62S	14S	24S	75S
Under 2	0.040	0.040	0.040	0.050
2 to (not incl) 3	0.045	0.050	0.050	0.062
3 to (not incl) 4	0.050	0.050	0.062	0.078
4 to (not incl) 5	0.062	0.062	0.078	0.094
5 to (not incl) 6	0.062	0.078	0.094	0.109
6 to (not incl) 7	0.078	0.094	0.109	0.188
7 to (not incl) 8	0.094	0.109	0.125	0.219
8 to (not incl) 10	0.109	0.125	0.188	0.375
10 to (not incl) 12	0.156	....	....	....
12 to (not incl) 14	0.188	....	....	....

**14,000-Ton Press

Circumscribing circle size, in.	*Minimum thickness, in.		
	61S-62S	14S	24S-75S
Under 13	0.109	0.125	0.156
13 to (not incl) 16	0.125	0.156	0.187
16 to (not incl) 19	0.140	0.171	0.250
19 to (not incl) 23	0.156	0.187	0.375

*These manufacturing limits apply to the average shape. Thicknesses greater than standard may be necessary for some shapes and thicknesses less than standard may be possible for others.

**Notes:

(1) Maximum weight per piece ..... 2500 lb
(2) Maximum length per piece, heat treated ..... 110 ft

PRODUCTION EXPERIENCE

The unprecedented size of the 14,000-ton extrusion press made it impossible to predict exactly how the unit would perform in production. In fact, the full production advantages of the big press will not be realized until production specialists and engineers have had time to try out all of its capabilities.

During early runs under both engineering and production control, a number of facts concerning press production capability have been established. From these facts, Table I has been formulated. This table, which contains "manufacturing limits" for extrusions produced on the press, shows the limits on extrusions produced from 5200-ton capacity and smaller extrusion presses. It is reasonable to expect that this data will be refined as more operating experience is acquired. The 5200-ton press that is installed at Lafayette Works was one of the largest operating in the United States prior to the installation of the 14,000-ton press.

Tooling costs — Tooling costs for extruded shapes have always been low, and the advent of the 14,000-ton press has not changed this favorable situation. Obviously larger sections require larger and more expensive tooling, but the cost of extrusion continues to be less than that for any other method of fabrication. The employment of a standard series of adapters serves to minimize tool costs in many instances.

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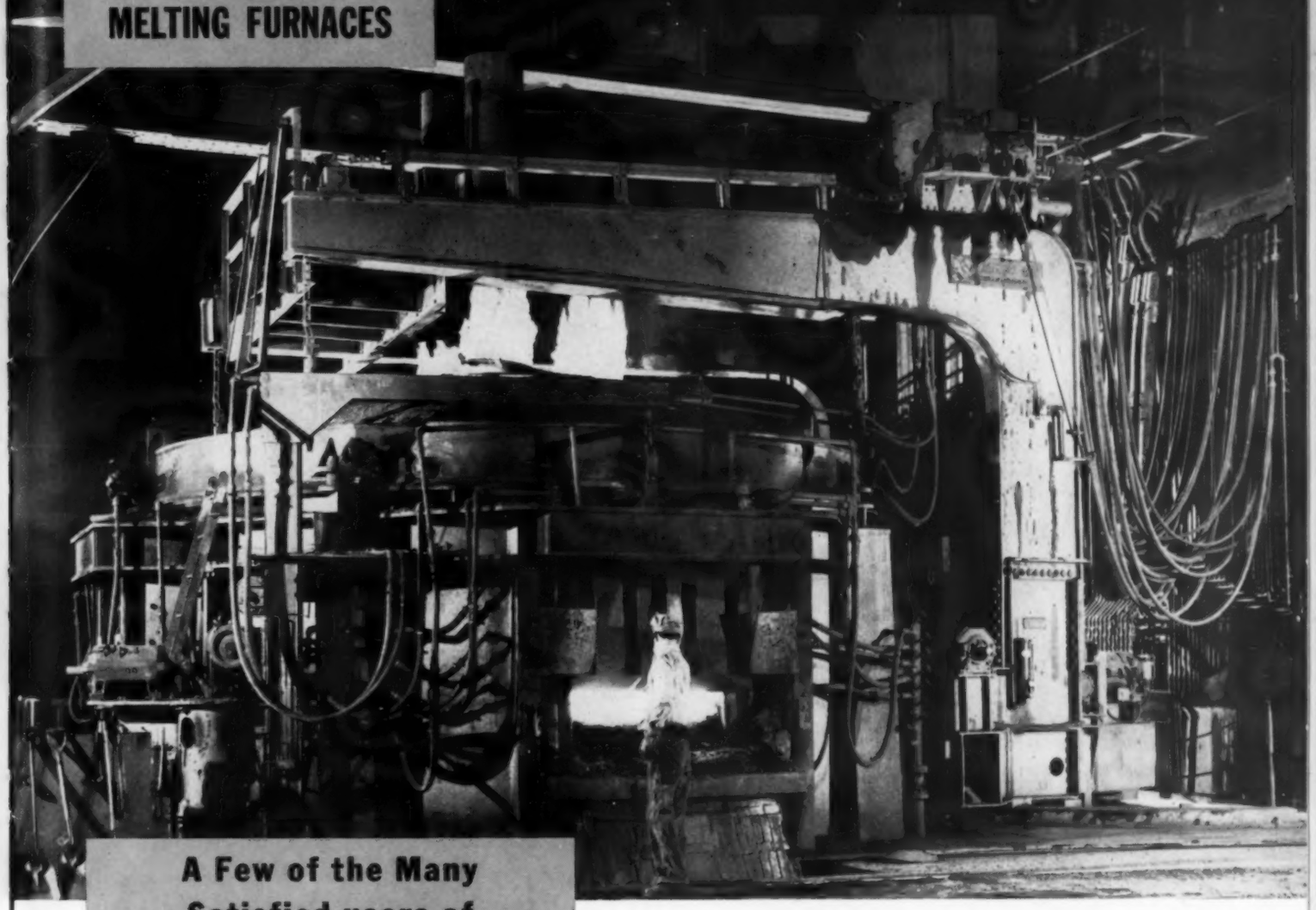

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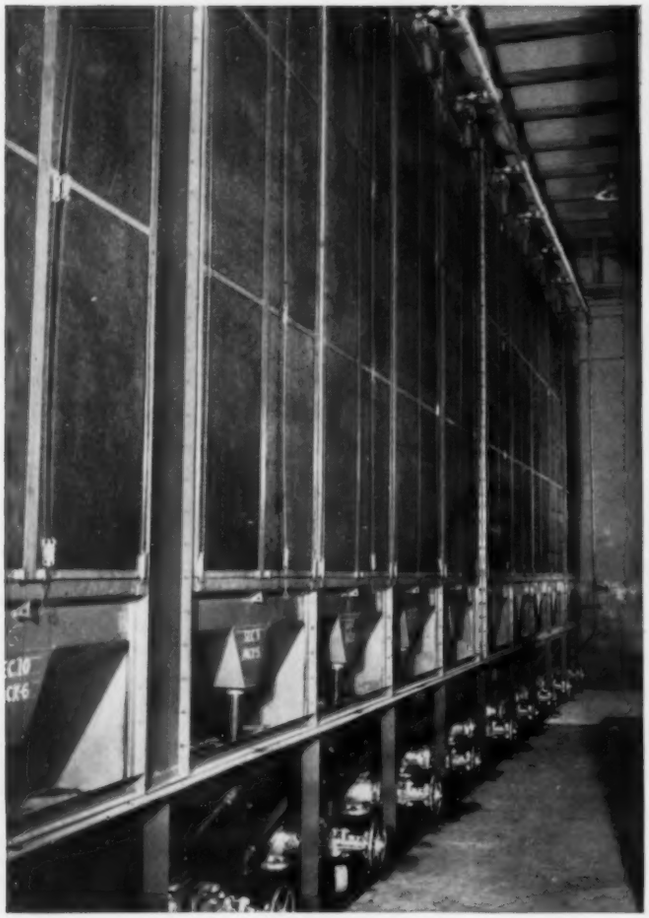

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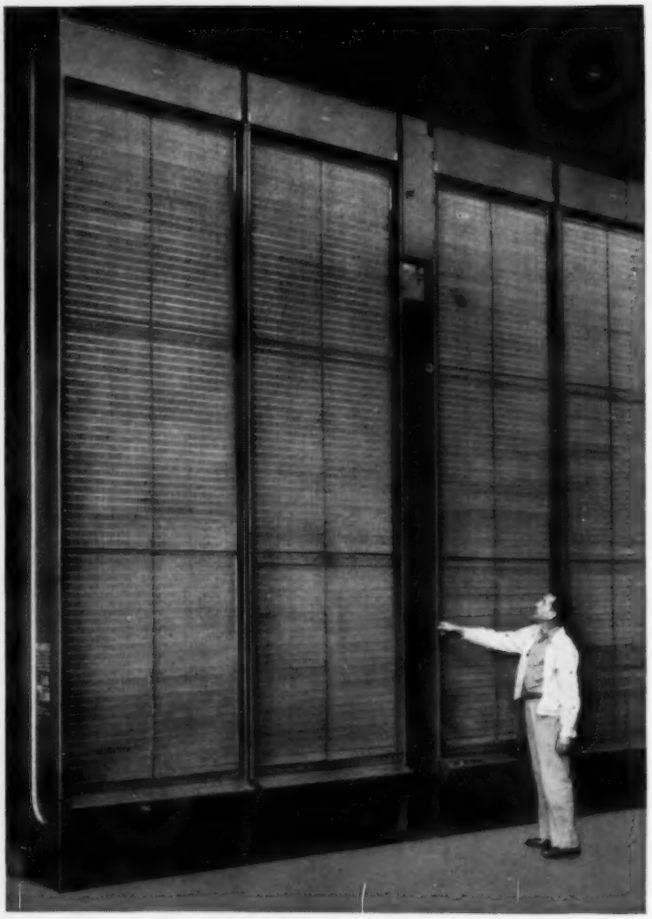

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MILLS AT FAIRLESS USE NEW METHODS

By G. E. FARRINGTON
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. . . equipment at Fairless symbolizes steel management's efforts to provide better quality material at lower prices . . .

▲ AS everyone is well aware, pickling is an unpleasant, though at present, necessary process in the manufacture of steel. It's function of removing oxides from the outer surfaces of the metal before cold rolling and final processing, makes its use a requirement on all products needing a clean scale-free surface. Various methods have been tried in the past few years — some with fairly good results, but high cost — and others with a lesser degree of success.

The newest and most simple method to be tried to date involves the use of a two-high temper mill installed directly in the pickle line. Coils are processed at the entry end of the pickle line in the normal manner, passing through the processor, welder, wash and loop pit. At this point, a two-high 32 × 80-in. face temper mill is placed in the line and an elongation of two to three per cent is made upon the strip. This elongation definitely breaks a considerable amount of scale not loosened by the processor and lessens the amount of acid dip required to clean the surfaces of the metal.

Figure 1 — The 2-high temper mill installed in the pickle line reduces the amount of acid dip required.

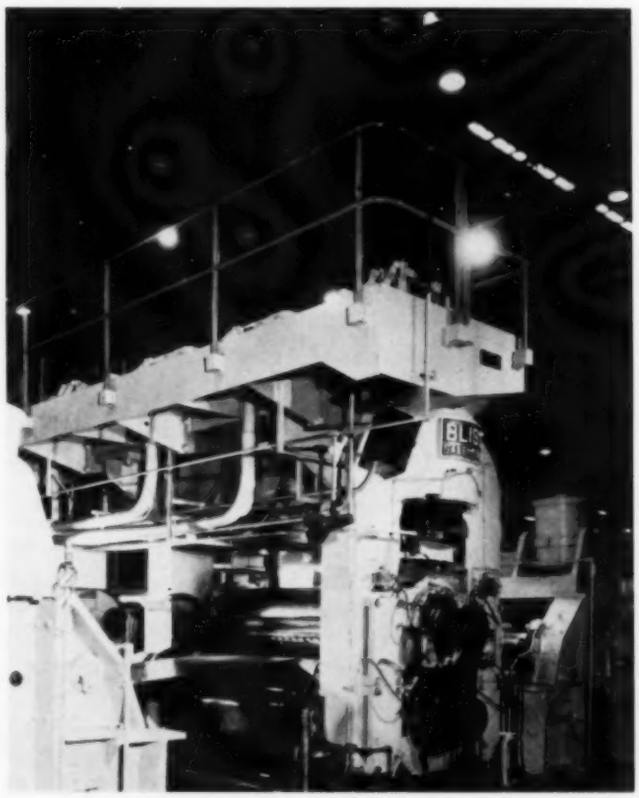

Figure 2 — A 2-high temper mill is also installed on the slitting and shearing line to apply the proper temper to the finished sheets or coils.

The two-high mill was designed for this operation and is powered with a single 350-hp, 600/1200 rpm, d-c variable voltage motor driving through a combination reduction gear and pinion stand with universal spindles to both top and bottom rolls. Two 75-hp mill type motors power the screwdown and, through a reduction of 227 to 1, operate the 15-in. diameter screws. Selsyns and productimeters give the operator the exact setting of the top roll and the amount of extension or elongation is continuously shown on a meter conveniently located in the operator's vision. The mill was geared to give ample speed for matching the line speed, as the mill is to provide a safe margin for inspection of the strip at the mill, and also to build up a sufficient amount of stock in loop form in the water pits on the delivery side of the mill. Roll neck bearings of the tapered roller type were furnished and the amount of rolling pressure exerted by each screw is indicated on meters on the operator's control desk. Spray headers for cleaning and cooling the rolls are provided, as well as gas retorts for affecting roll crown. Deflecting rolls and guides were furnished with design based on good strip inspection and ease of changing rolls while strip was threaded through the mill.

Results, to date, indicate increased efficiency in cleaning and processing and with modifications and additions, a bright future is forecast for this process, resulting from the combination of mill with conventional pickle line.

Another innovation in steel mill practice is applied at the Fairless Works on the slitting and shearing line. Here again, a two-high 32 × 80-in. face temper mill is installed for applying proper tempers to the finished sheets or coils. The mill is designed to handle strip up to 76 in. in width and is driven by a 150-hp, 600/1200 rpm, d-c variable voltage motor through a combination drive and pinion stand with both rolls connected through universal spindles. Screwdowns are connected through a magnetic clutch mounted on the 50-hp mill type motors. The 15-in. diameter screws are gear driven with a ratio of 1000 to 1 from the motors. Here again, accurate data is readily available to the operator through screw adjustment indicators on the control desk.

In the planning and design stage of the two-stand 19 & 53-in. × 48-in. four-high tandem temper mill, the handling of coils on the entry and delivery ends was of major importance. The final design incorporates a flat top pallet conveyor upon which six coils can be stored and fed to the cones. Here an elevator and inclined ramp position the coils, for accurate and easy insertion of each cone. The cones are each connected to a 150-kw, 300/1200 rpm, d-c drag generator through specially designed reduction units incorporating high capacity thrust bearings. The cones are traversed either individually or together by means of two 25-hp mill type motors through a connecting magnetic clutch. The hoist is raised and lowered hydraulically.

The two mill stands are each directly driven through thrust bearing stands and universal spindles with no mechanical connections between top and bottom work rolls. The first stand is driven by four 150-hp, 575/750-rpm, d-c motors and the second stand by four 200-hp, 575/750-rpm, d-c motors. Screwdowns on both stands are driven by four 75-hp mill type motors with variable field for rapid screw travel during roll changing. The position of the 18-in. diameter screws is clearly indicated on 24-in. diameter dials mounted on the drive side of the mill under the screwdown girder. Tension between stands is indicated by means of an electric tension measuring device.

On the exit side of the mill are placed a pair of delivery tension rolls, independently driven by a total of three motors. Two 200-hp, 425/550-rpm, d-c motors drive the top tension roll and only one is connected to the bottom.

The 16½-in. diameter reel block is driven through a single reduction gear unit and flexible couplings by two 200-hp, 300/1200-rpm, d-c motors connected in tandem.

Strip is fed from the delivery tension rolls to the reel and horizontal belt wrapper by a guide operated automatically by the belt wrapper position.

A hydraulically hoisting and traversing coil buggy strips the coil from the collapsed reel and deposits it on a pallet type delivery conveyor. From here, the coils are transported by "C" hook and crane or ram truck for shipping or further processing.

A separate entry and delivery hydraulic system feeds the equipment on both ends of the mill and two automatic full filtration lubricating systems lubricate the oil lubricated backup roll neck bearings and thrust stands, reduction units, and drives.

Rolls are changed by "C" hook and balance bar and the entire installation is automatically greased from a central point at preset time intervals.

A coupon punch stamps out circular samples of strip at speeds up to 1000 fpm for use in the laboratories to determine if quality is correct.

The installations, as described above, symbolize steel management's ever increasing desire to provide a material of better quality at a lower price and with the utmost safety to the men who produce this product.

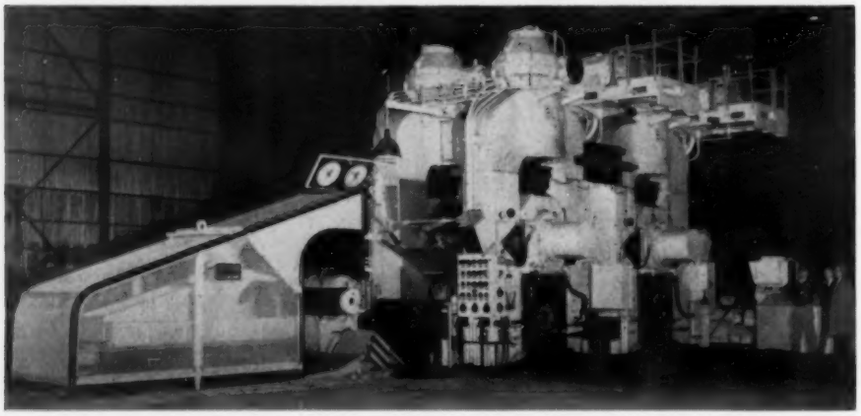

Figure 3 — In operation also is a 2-stand 19 and 53 in. x 48 in., 4-high tandem temper mill.

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F-85 F-C

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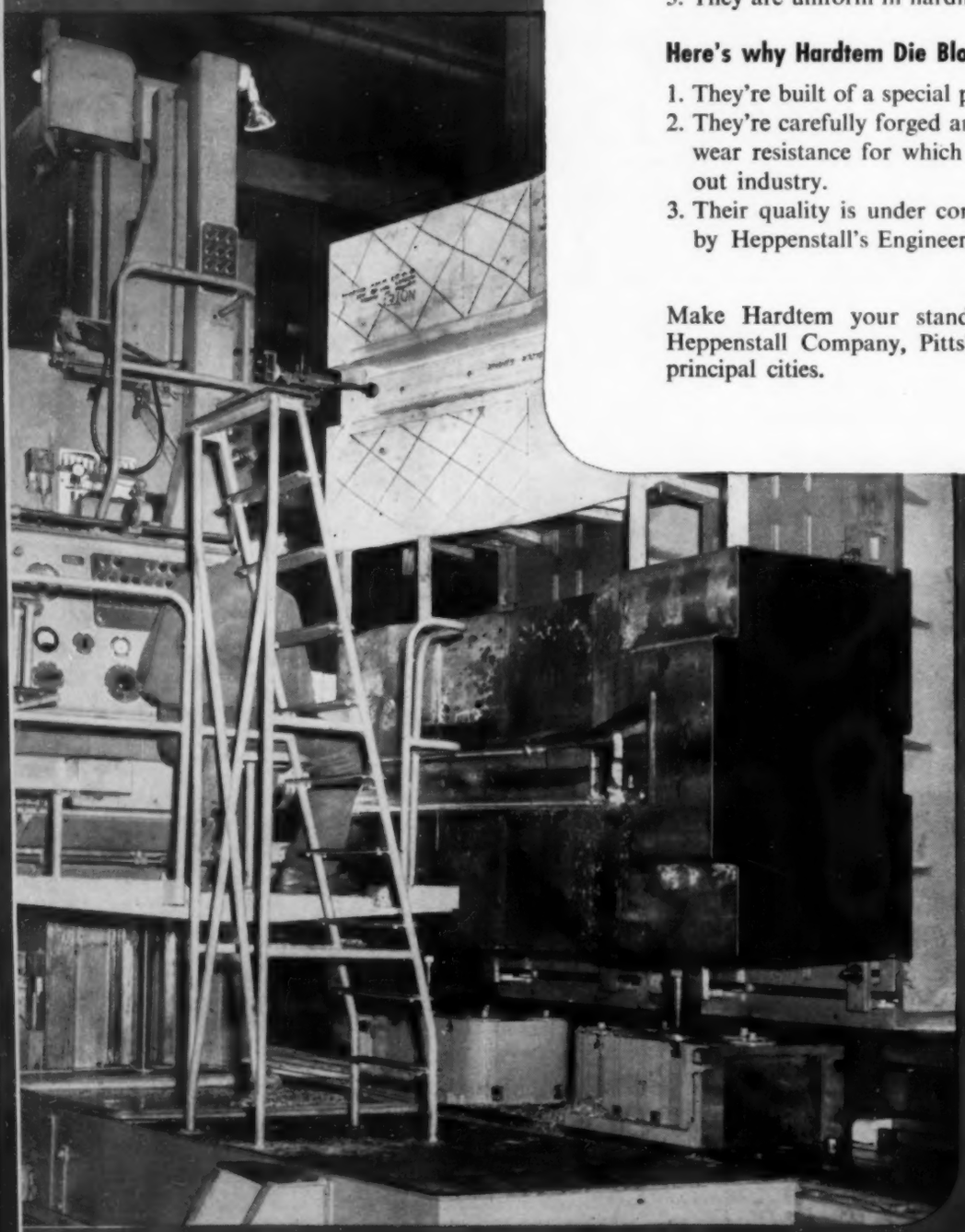


H

Heppenstall

. . . the most dependable name in die blocks

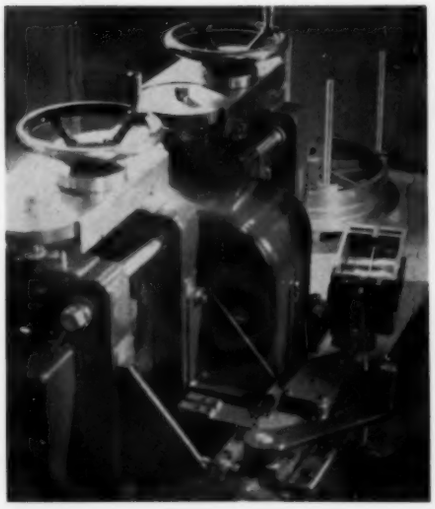
PACKAGED ROLLING MILL AIDS RESEARCH

▲A complete experimental strip, rod, and wire mill in one machine is saving valuable production mill time as well as expanding the metallurgical research facilities of the laboratory, according to officials of the Research Laboratory of the General Cable Corp., Bayonne, N. J.

To meet General Cable's needs, this mill was designed by engineers of Stanat Manufacturing Co., Long Island City, N. Y., as a combination of three different machines: (a) a standard 4 x 6-in. two-high strip mill; (b) a 4 x 6-in. two-high rod mill; and (c) a 16-in. diameter bull block for drawing wire. By mounting the strip mill, rod mill, and bull block on a single stand, maximum utilization of space and manufacturing economy is achieved. Still another feature of the mill is a set of vertical edging rolls which is mounted on the strip mill portion of the machine for conditioning stock edges.

The new mill handles experimental ingot, rod, round and flat wire. As such, the mill solves a problem which is basic in many industrial laboratories. Heretofore, whenever an experimental ingot was handled, or a pilot run of a new metal or alloy was made, it was necessary for laboratory personnel to use actual production equipment in the plant. This interfered with production, and usually meant a costly tie-up in large sections of the plant. The new combination mill offers a practical solution to this problem.

Figure 1 — For drawing wire, the bull block attachment is used.

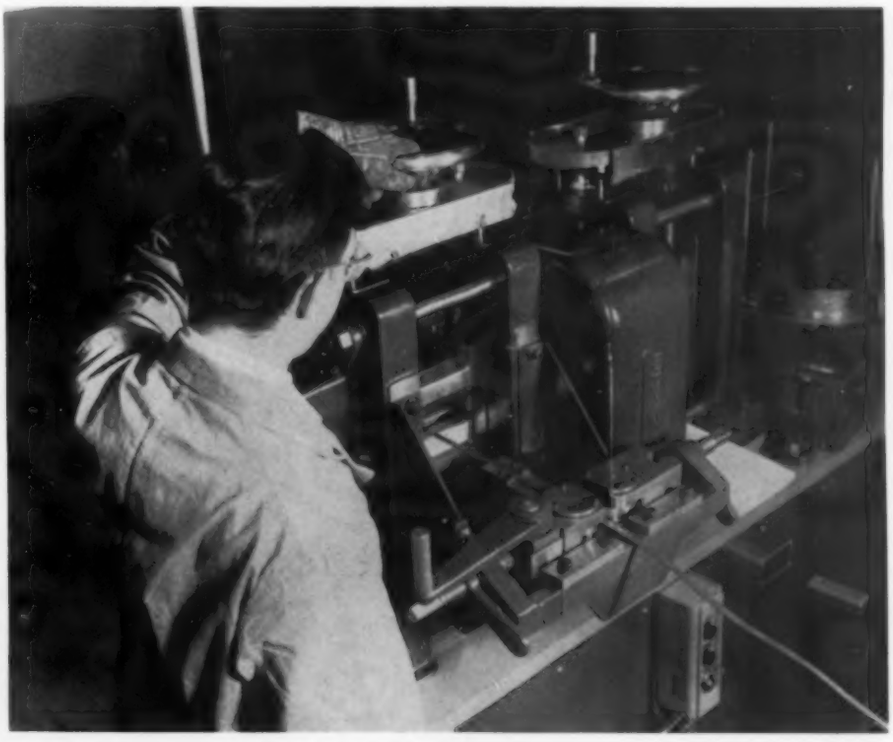


TYPICAL OPERATIONS

Use of the mill in General Cable's laboratories allows testing and pilot production of various copper and aluminum alloys in complete sequence from ingot to finished product. In a typical sequence, aluminum or copper-base alloy ingot is broken down in the rod mill portion of the machine. It is then drawn down to smaller size, using the bull block attachment; and finally rolled into flat wire using the strip mill portion of the machine in conjunction with the vertical edging rolls.

In a typical day's work at the General Cable laboratories, three diversified types of operation were carried out. First by using the bull block alone, brass wire was drawn from 0.081 in. diameter down to 0.0725 in. diameter. Next, in another operation, a sample of rectangular copper wire 0.100 in. thick x 0.400 in. wide was

Figure 2 — Cold rolling and edging form a sample of rectangular copper wire, 0.100 in. thick x 0.400 in. wide.



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Integrated high capacity heat treating lines, featuring the pressure quench, produce FLAT high quality plate . . . .
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produced from what was originally a round wire.

A third operation in this "typical" laboratory day was the hot rolling of experimental copper and aluminum alloys. An aluminum ingot was hot rolled in the grooved rolls of the combination machine. For this work, all such mills can be furnished with two sets of interchangeable rolls, one for hot rolling and one for cold rolling.

FEATURES OF MACHINE

This combination flat and wire mill with bull block attachment is available in various models and sizes. General Cable uses the Stanat Model CXBB-200, which has a 4-in. roll diameter with a 6-in. face width. Further specifications are as follows:

CXBB-200

Combination mill with bull block attachment

Roll size:	
Diameter, in.	**4**
Face width, in.	**6**
Opening between flat rolls, in.	**1**
Diameter, bull block, in.	**16**
Motor, hp	**7½**
Weight (approx), lb	**2800**
Floor space, in.	**24 x 64**

One of the most striking features of the machine is its clean and functional appearance, which meets the needs of most industrial laboratories. The fabricated steel base which carries all three mill units, fully encloses the motor and transmission. The bull block is driven from the mill motor through a multiple disc clutch, and can be disengaged when not in use; the clutch lever is conveniently located at the front of the machine. To obtain a right-angle drive to the bull block unit, a heavy duty flood lubricated worm reduction gear box is employed.

Each detail of the machine is designed for heavy duty use. Roll housings, for instance, are made from high tensile alloy for great strength and rigidity. These are designed with a high factor of safety to take loads far in excess of usual requirements, with minimum deflection. The rolls themselves are made from close-grain alloy tool steels, expertly hardened, precision ground and polished. For hot rolling, special rolls are made from tool steels which maintain excellent hardness and toughness properties at elevated temperatures. In addition to mechanical shock, they withstand severe thermal shock without softening.

Figure 3 — Hot rolling is also done on the mill.

Heavy duty bearings are made of a special bronze alloy, designed to resist extreme pressures. Full provision is made for thrust as well as radial loads. Mills can also be equipped with roller bearings. The rolls are coupled by idler gearing, which permits stock thicknesses up to 1 in. to be rolled. Gear centers are placed in a manner that permits backlash to remain constant for any roll setting. This results in finer finishes, and permits repeated regrinding of rolls without the danger of pitchline interference of roll coupling gears.

Both mill units on the machine are provided with a single hand-wheel screwdown, which adjusts both sides of the roll simultaneously. Roll parallelism is easily altered by lifting the center gear out of mesh, making the adjustment and then reengaging.

To obtain a choice of speeds within a ratio of 4 to 1, the machine is equipped with a four-speed gear shift drive, operating from a 220/440, 3-phase, 60 cycle a-c supply.

One of the most valuable features of the machine, developed in answer to the needs of such laboratories, is the pair of vertical edging rolls located at the entry side of the strip mill portion of the machine. Designed specifically to facilitate experimental work, this edging stand uses easily exchanged idler rolls mounted in heavy-duty tapered roller bearings. Each roll has its own individual screwdown adjustment. Another feature of the edging unit, making for convenience, is the quick acting cam-type mechanism which allows easy threading of the material at the start of the rolling operation.

For wire drawing purposes, the machine is equipped with a compact die holder and oiler. In this device, stock passes over and under rollers which are completely submerged in oil, imparting beneficial straightening as well as oiling of the stock prior to the rolling operation.

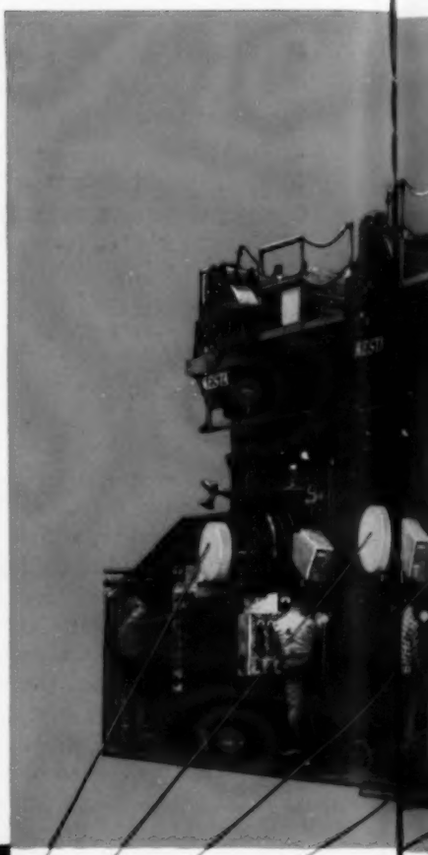
Back-up roll bearings of get effective lubrication with GULF I-C

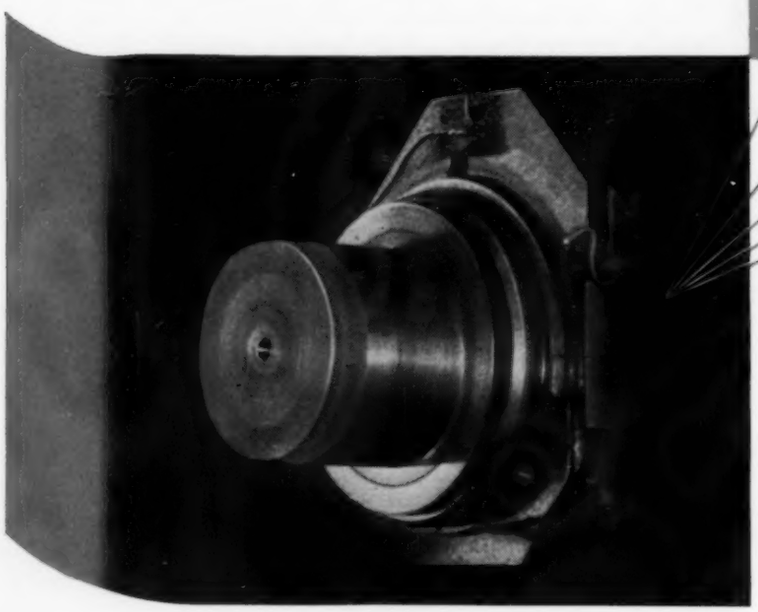
Back-up roll bearings of this cold strip mill at U.S. Steel's new Fairless Works, the world's fastest, require the best possible lubrication to withstand heavy loads over a long period of time. The strip shoots through the rolls at speeds up to 7000 feet per minute.

Gulf I-C Oil provides the effective lubrication that is needed here. This stable oil has excellent water separating characteristics, and resists sludge formation. These important advantages—plus outstanding lubricating qualities—contribute to continuous operation and lower maintenance costs.

Gulf I-C Oil was also selected to lubricate the back-up roll bearings of the new and efficient hot strip mill at the Fairless Works.

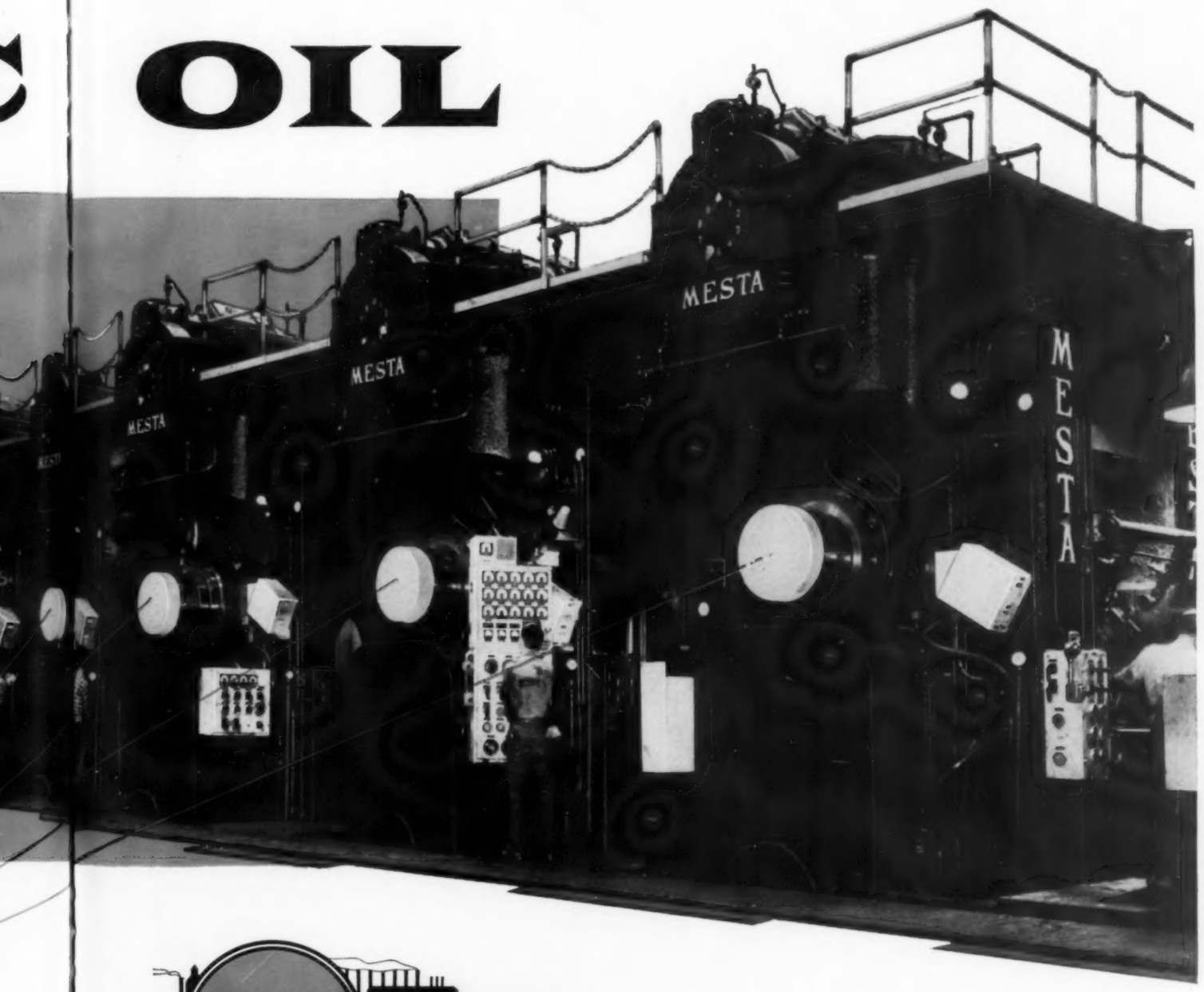
Whether your mill operates at a speed of 7000 or 700 feet per minute, make your next order for a roll bearing lubricant an order for dependable, efficient lubrication by specifying Gulf I-C Oil. Call your nearest Gulf office today and ask a Gulf Sales Engineer to recommend the proper grade for your equipment.





world's fastest cold strip mill

OIL



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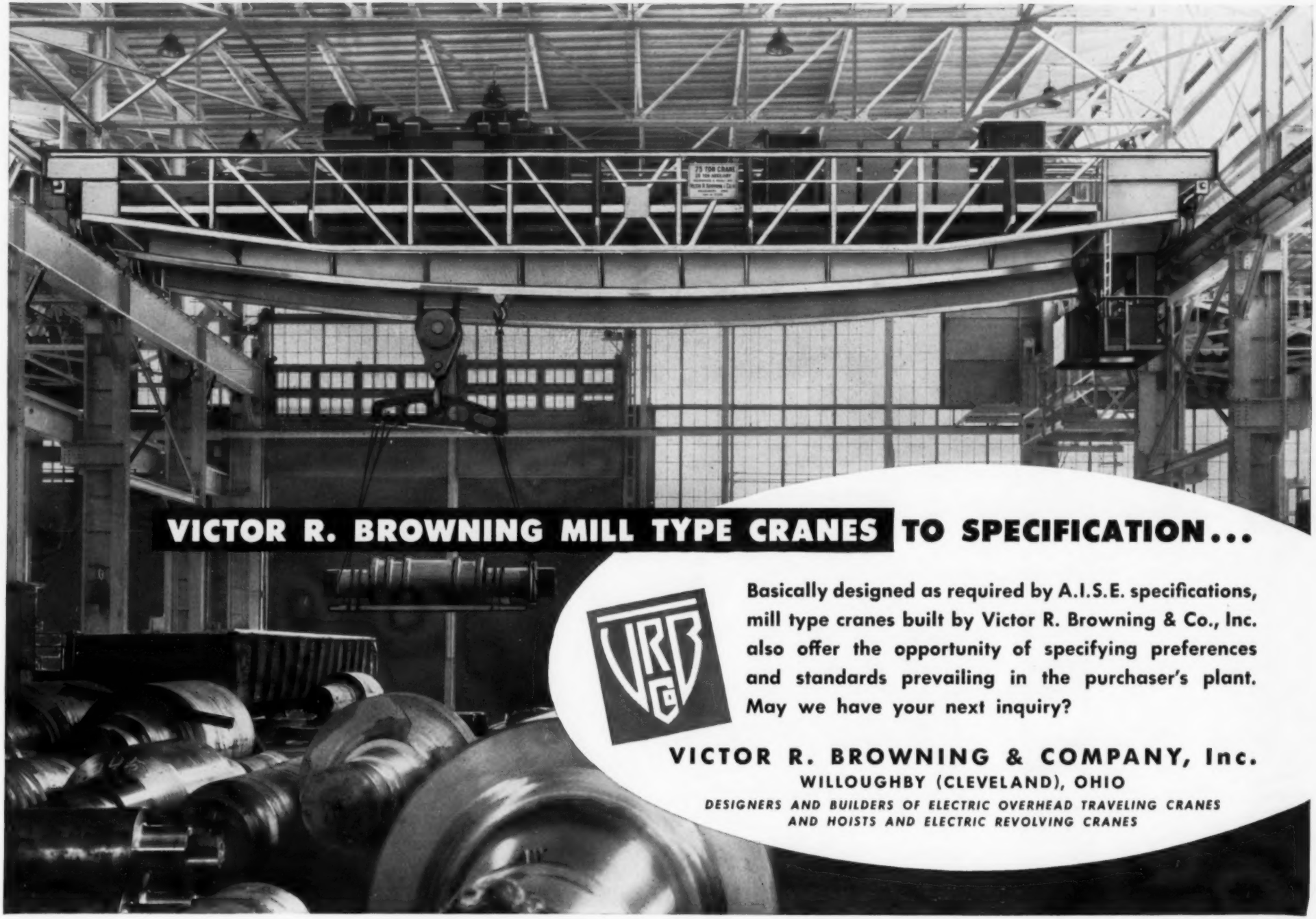

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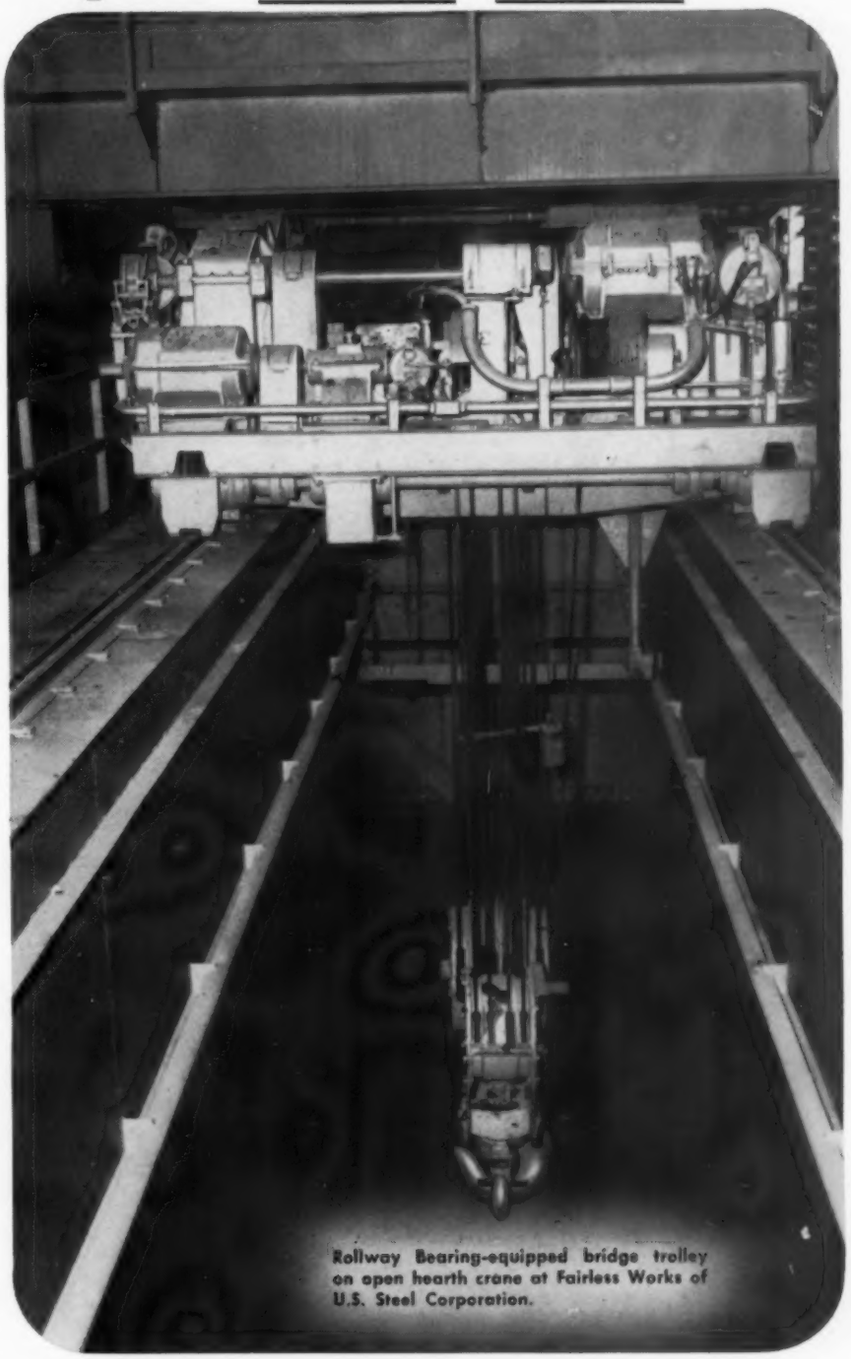
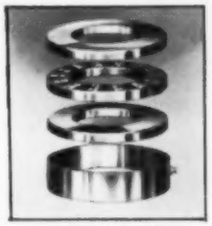


Rollway Bearing-equipped bridge trolley on open hearth crane at Fairless Works of U.S. Steel Corporation.

THRUST Type AT Single-Acting Aligning

RADIAL Type MUC Separable Inner Race



THRUST Type WCT Crane Hook with Alemite Grease Fitting

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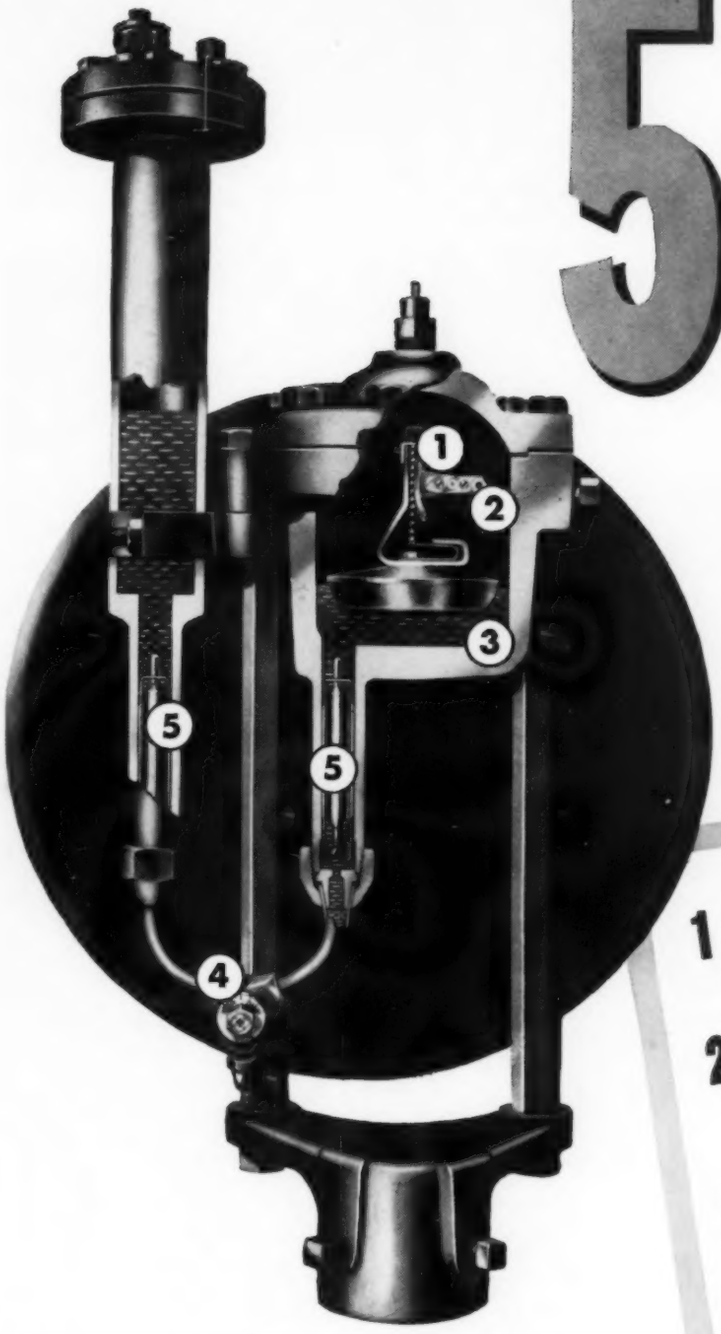

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Pickling tank and wash tank at Laclede Steel Company. Note the rolls fabricated from tough corrosion- and wear-resistant Ampco Metal. Roll dimensions 31" OD x 29" ID x 36" long. Side plates 34½" OD x ½" thick with 5" ID for shaft.

Here's another roll used at Laclede. Fabricated from money-saving Ampco Metal, it handles six strips at a time.

Laclede Steel
fights wear and corrosion in its pickling line with
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...keeps production up...costs down

Steel companies throughout the country are faced with terrific production problems. Laclede Steel Company, St. Louis, like so many others, found one answer in Ampco Metal.

Shown here is their pickling operation. The tank carries a 12% sulphuric acid solution at 200°F. The strip enters the tank and goes through the entire process via wear- and corrosion-resistant Ampco Metal rollers.

The rollers and side plates are fabricated from Ampco Grade 8 plate. Shafts and nuts are made from extruded Ampco Grade 15.

But resistance to corrosion in pickling service isn't the only important feature of Ampco Metal. It also resists wear, shock, impact. That's why so many mills use Ampco Metal screw-down nuts, slippers, wear plates, flash-welder dies.

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"This light-colored oil did the trick. DOWN TIME WAS CUT IN HALF AND DRILL LIFE INCREASED OVER 200%!

"We use Cities Service Chillo 44 to machine all types of metals covering a range of machinability from brass to stainless on our Brown and Sharpe 00G, 0G and 2G Automatics. It has proved to be the difference between ordinary and quality production in our shop!"

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Date-line Diary...

May 1

▲ Sharon Steel Corp. reported gross sales of $23,913,260 and a net income of $70,716 for the first quarter in 1954 as compared with gross sales of $46,499,190 and a net income of $2,051,826 for the like period of 1953.

May 3

▲ The AISI reports operating rate of the steel industry for the week starting May 3 is scheduled at 67.3 per cent of capacity. This is equivalent to 1,604,000 tons as compared with 1,637,000 tons one week ago and 2,259,000 tons one year ago. Index of production for the week is 99.9.

▲ Steelworkers at Weirton Steel Co. declined another of the many bids from the CIO United Steelworkers union to negotiate an agreement covering employees at the Weirton Steel Co. This company holds a strike-free record for over 20 years. As a result the CIO asked the NLRB for an election.

▲ According to the Federal Reserve Board, consumer credit outstanding on March 31 declined to $27,-200,000,000, a decrease of $327,000,000 during the month as compared with a $442,000,000 increase in March 1953.

▲ The Government has scheduled a large shipbuilding program which calls for expenditures of $400,000,000 yearly thus providing jobs for 36,000 workers.

▲ Increased demands of copper resulted in stepping up operations at four of Kennecott's mines in Utah, Arizona, New Mexico and Nevada. This will hike refined copper output by 5000 tons monthly to the total of 25,000 tons. Kennecott's March quarter net profit declined to $1.70 a share from $2.01 one year ago.

▲ According to the Commerce and Labor Depts., construction outlays in April rose to $2,800,000,000, up 1 per cent above one year ago.

▲ Personal income for March fell to an annual rate of $282,800,000,000, which is $800,000,000 below the March 1953 pace, as reported by the Commerce Dept.

▲ U. S. Steel Corp. agreed to begin discussions with the CIO United Steelworkers in Pittsburgh on May 18 regarding the new contract to replace the one expiring on June 30.

▲ The Aluminum Association reported primary production of aluminum in March totaled 244,678,349 lb compared with 220,965,786 in February and 208,-919,425 in March one year ago.

May 6

▲ Pig iron production in Canada for February 1954 amounted to 182,050 net tons compared with 214,999 tons in January 1954. February production included 146,980 tons basic iron, 3092 tons foundry iron and 31,978 tons malleable iron.

▲ The Commerce Dept. reported business inventories in March rose to $81,100,000,000 or $1,600,000,000 greater than the March 1953 figure. Business sales in March totaled $47,700,000,000 or $4,600,000,000 above February.

▲ United States Steel decreased prices on grades and sizes of stainless steel sheet and strip produced by the continuous cold reduction method while it placed increases on grades and sizes made on hand mills.

May 7

▲ The Engineering News-Record declared private housing construction contracts awarded for the week ending May 6 rose to almost $240,000,000.

▲ The House with a vote of 241 to 158 passed the controversial project that will link the Great Lakes with Atlantic shipping.

▲ Deliveries of new domestic freight cars in April 1954 totaled 4038 compared with 4823 in March and 6839 in April 1953 the ARCI announced today. Orders in April totaled 909. Backlog of cars on order as of May 1, 1954 was 17,817 compared with 20,966 on April 1.

May 8

▲ Government figures show that total employment in early April expanded to 60,598,000, an increase of 498,000 over the comparable March level.

May 10

▲ The AISI reports operating rate of the steel industry for the week starting May 10 is scheduled at 68.6 per cent of capacity. This is equivalent to 1,636,000 tons as compared with 1,654,000 tons one week ago and 2,262,000 tons one year ago. Index of production for the week is 101.8.

April 11

▲ Under a bill approved by the House Ways and Means Committee, copper imports will remain duty-free until June 30, 1956.

May 12

▲ The Commerce Dept. reported U.S. exports in the March 1954 quarter were valued at $3,400,000,000, down 13 per cent from one year ago.

May 13

▲ A report of the F. W. Dodge Corp. states April contract awards for future construction in the 37 eastern states was $1,691,868,000, about 11 per cent above March.

▲ Bethlehem Steel Co. announced plans to build a $4,000,000 to $5,000,000 fabrication plant near Los Angeles.

▲ General Motors plans to build a new Fisher Body plant at Livonia, Mich.

▲ The Senate Finance Committee decided to continue the 52 per cent corporate tax rate from April 1, 1954 to March 31, 1955.

May 14

▲ According to the Commerce Dept., national production of goods and services in the March quarter fell to a yearly rate of $357,800,000,000, 1.5 per cent below the last three months of 1953.

May 17

▲ The AISI reports operating rate of the steel industry for the week starting May 17 is scheduled at 70.0 per cent of capacity. This is equivalent to 1,668,000 tons as compared with 1,690,000 tons one week ago and 2,250,000 tons one year ago. Index of production for the week is 103.8.

▲ Home construction contracts this year are expected to reach the second largest total in history. From 1,000,000 to 1,100,000 new dwellings are anticipated. Private housing projects in April ran at an annual rate of 1,159,000, a gain of 18,000 units over April one year ago.

▲ Unemployment compensation claims mounted to 327,200 during the week ending May 8, according to the Labor Dept.

May 19

▲ The Office of Defense Mobilization granted a six month extension to the New England Steel Development Corp.'s certificate of necessity which authorized rapid tax amortization on $20,502,000 worth of steel plant equipment.

▲ The United States held steel mill owned by Czechoslovakia has been sold to Sociedad Mixta Siderurgia Argentina, Buenos Aires with a bid of $9,000,000. This equipment will be used in a new plant being built near Buenos Aires in line with a general movement to expand Argentine steel industry.

▲ United States Steel Corp. and CIO Steelworkers began contract negotiations in Pittsburgh with the union demanding higher pay, expanded pensions and social security plan and a modified guaranteed annual wage.

▲ Pittsburgh Consolidation Coal Co. recently announced its plans to build a coal-hauling pipeline from mines in eastern Ohio to near Cleveland.

▲ Inland Steel Co. increased its pig-iron production at its Indiana Harbor, Ind. plant by reopening the blast furnace it idled on February 13.

May 20

▲ Republic Steel Corp. has announced a new pricing method for cold rolled carbon bars.

▲ According to the F. W. Dodge report, contract awards for schools and colleges in April in the 37 eastern states totaled $156,554,000, a new record for any April in the Dodge history.

▲ The basic commodities of copper, crude oil and steel scrap increased sales substantially during the past month.

▲ Heavy melting steel scrap advanced $1 to $30 a ton in Pittsburgh which price is $5 a ton above its low reached early in March.

May 21

▲ According to the ODM, seven stockpile materials are under short supply, and export is limited. They are chromium, cobalt, columbium-tantalum, diamond bort and grinding wheels, hog bristles, nickel and selenium.

▲ United Steelworkers of America served notice it does not want to be labeled as a CIO union.

▲ Machine tool shipments in the March 1954 quarter dropped 13 per cent from a year ago to $328,400,000.

▲ Anaconda Copper signed an agreement with the Government to deliver 64,000 tons of Chilean copper to the U. S. stockpile at 30¢ a lb. They are negotiating to sell 36,000 tons on the same terms.

▲ U. S. Steel Corp. and the United Steelworkers recessed negotiations for about two weeks for consideration by the corporation to the union's proposals for higher pay, improved pensions and social insurance, and the guaranteed annual wage.

May 24

▲ The AISI reports operating rate of the steel industry for the week starting May 24 is scheduled at 70.5 per cent of capacity. This is equivalent to 1,680,000 tons as compared with 1,712,000 tons one week ago and 2,262,000 tons one year ago. Index of production for the week is 104.6.

▲ The Chicago Mercantile Exchange voted to open trading in scrap iron and steel on or before August 1.

▲ Birdsboro Steel received an offer for its assets of $20 a share and with 198,500 shares of outstanding stock the amount would be $3,970,000 for its assets. Net sales for this company in 1953 were $12,647,465 with a net income of $493,580. Net sales for the March 1954 quarter were $2,920,686 with a net income of $129,795.

May 25

▲ General Electric offered its 220,000 employees a 2.68 per cent pay hike. This would average slightly more than 5¢ an hr with a minimum of 4¢ an hr.

▲ The House Ways and Means Committee voted to increase the Social Security tax rate from 2 per cent to 2½ per cent by 1960 with a rising percentage to 4 per cent by 1975 and later years.

▲ The agriculture department reported farm income in April fell to $1,900,000,000, down 5 per cent from March.

May 26

▲ April shipments of fabricated structural steel amounted to 290,353 tons according to the American Institute of Steel Construction. Total shipments for the first four months of 1954 was 1,074,466 tons. Bookings in April totaled 182,859 tons. Backlog of work ahead as of April 30 stands at 1,566,214 tons.

▲ A report of the Commerce Dept. stated that U.S. investments abroad were valued at $39,400,000,000 at the end of 1953 which more than doubles the $18,700,000,000 invested in 1946.

May 27

▲ The Senate Finance Committee boosted the maximum annual deduction for mine exploration expenditures from $75,000 to $100,000.

May 28

▲ National Tube Div. of U. S. Steel Corp. started installation of equipment to make plastic pipe at its Gary, Ind. works. They plan to start production by fall.

▲ General Electric Co. will begin construction this year of a $5,000,000 plant at Shelbyville, Ind. to produce industrial furnaces, induction heating equipment and heating devices.

May 31

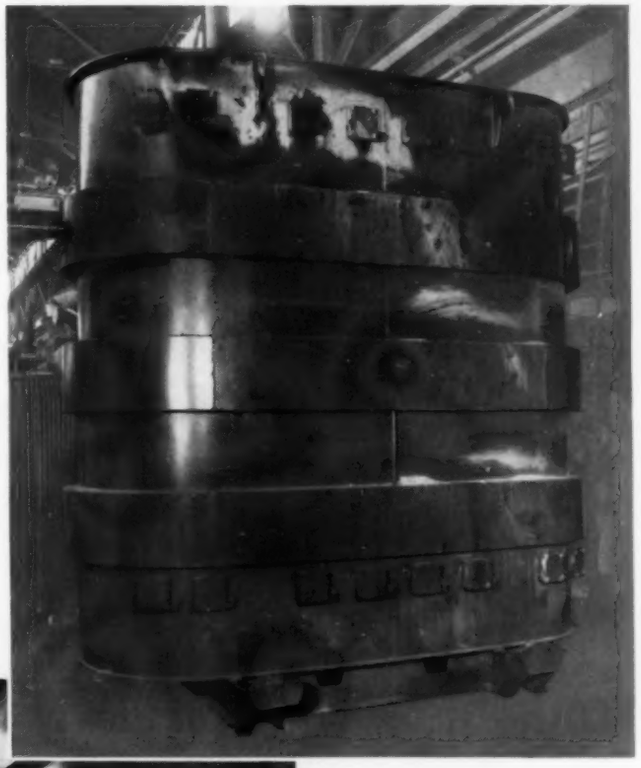
▲ Purchases of iron and steel by the nation's Class I railroads in 1953 amounted to over $612,000,000 according to the Association of American Railroads in Washington, D. C.

▲ The Sunbury Wire Rope Manufacturing Co., Sunbury, Pa. has sued U. S. Steel and eight other large wire rope makers for violation of the Sherman and Clayton Anti-Trust laws. Sunbury shut down its plant in March 1954. They are asking treble damages of about $7,755,000.

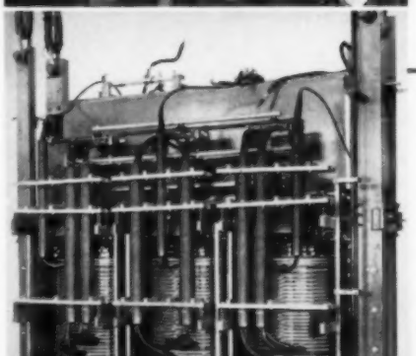
▲ Wheeling Steel reported net profits for the March 1954 quarter at $1,135,386 compared with $2,962,388 for the like period in 1953. Steel ingot production during this quarter for 1954 was 387,548 net tons, equivalent to 73.8 per cent of rated capacity.

▲ The AISI reports that operating rate of the steel industry for the week starting May 31 is scheduled at 70.9 per cent of capacity. This is equivalent to 1,690,000 tons compared with 1,698,000 tons one week ago and 2,246,000 tons one year ago. Index of production for the week is 139.8.

We don't like Accidents,



● Transformer tank withstood accident without damage.



● Inspecting engineer points out damaged base member.

● Electrical tests showed that no damage was done to the core and coils.

but, look what an accident showed us about our design

When the bridge is too low and the transformer traveling toward it is too tall, something is bound to happen when the two meet. And something did happen!

A depressed center car, carrying a Pennsylvania 7500 Kva Load Ratio Control Transformer, was switched from one track to another and coupled to the wrong train. Then it met up with the concrete bridge! After the dust cleared away, the transformer and car were found turned over on their sides.

When returned to our shop, the transformer was thoroughly inspected. Electrical tests showed that no damage had been done to the core and coils. Damage inside the transformer was negligible — a broken bushing lead and a few cracks in some wooden supports. *That's all!* The internal damage was slight *because* the core-and-coil assembly was rigidly supported and held by the core clamping frames — even when the transformer fell over on its side.

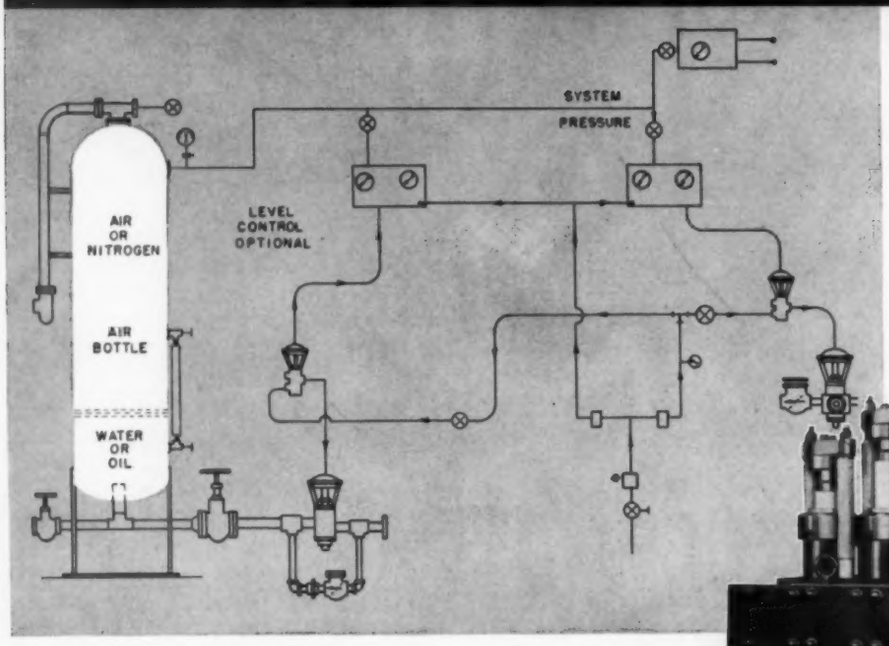
Externally, the load ratio control compartment was distorted, but the controls were undamaged. Two mounting panels of the underload tap changing switch were cracked. The front of the switching compartment was distorted, as was the nitrogen cabinet. Some of the transformer base members were bent and cut, and the portion of the cover that hit the bridge was dented.

That was the sum total of the damage. Repairs were made and complete electrical tests showed the transformer to be in excellent operating condition. It was shipped back to its destination and this time it stayed on the right track.

We believe the negligible damage that resulted from this accident is substantial proof of the extra mechanical strength built into all Pennsylvania Power Transformers.

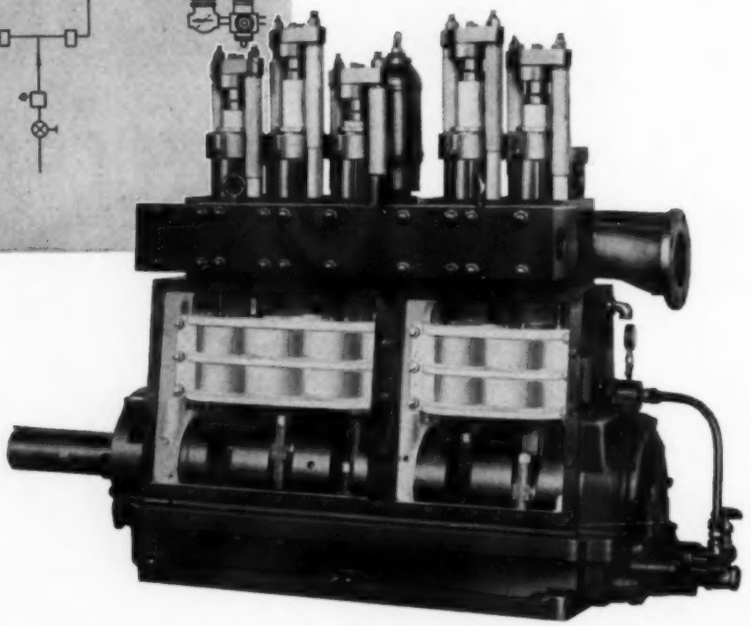
PENNSYLVANIA TRANSFORMER COMPANY
A McGraw Electric Company Division, **CANONSBURG, PENNSYLVANIA**
Greater Pittsburgh District

EFFICIENT-ECONOMICAL



One source of hydraulic power instead of many . . .

minimum investment
less maintenance and repair
greater efficiency
lower operating cost



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A single, concentrated source of efficient hydraulic power is wise economy and sound engineering. A single Aldrich Pump can supply all your presses and equipment—at a considerable saving. And if fire is a hazard, remember Aldrich design permits pumping *either* oil *or water*. Pumps are built in 3″, 5″, 6″ and 8½″ stroke, ranging from 24 to 2500 hp. Aldrich Pumps are integral parts of complete Aldrich Central Hydraulic Systems—designed to suit your needs and built to exacting standards.

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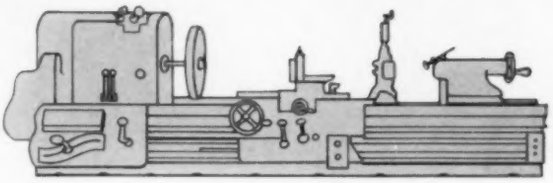
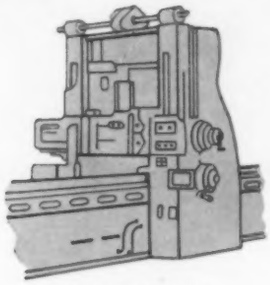
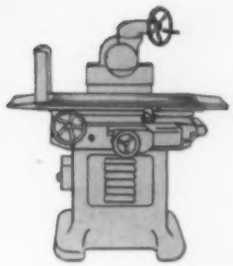
DID YOU KNOW...



ALL TYPES OF LATHES...



AND PLANERS



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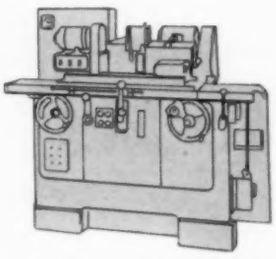
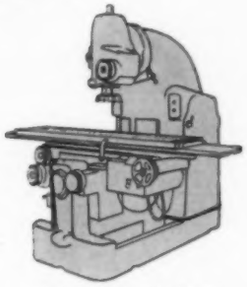
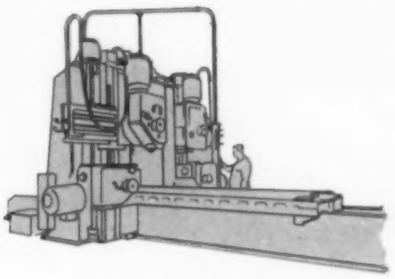


CYLINDRICAL GRINDERS



VERTICAL MILLERS



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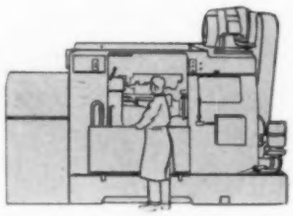
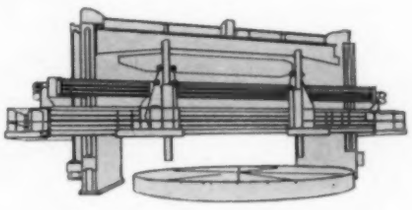
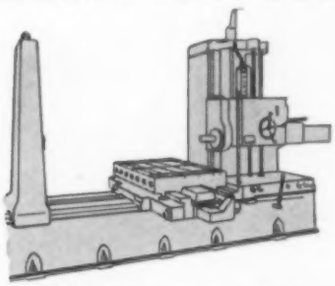


AUTOMATICS

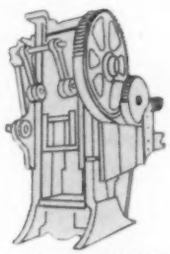


VERTICAL BORING MILLS

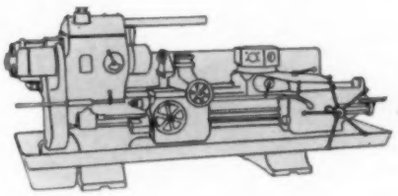


HORIZONTAL BORING MILLS

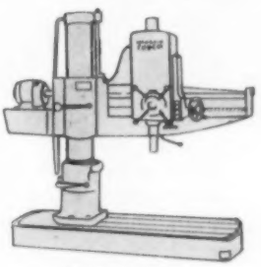
to meet manufacturer's original standards



ALL TYPES OF PRESSES



TURRET LATHES



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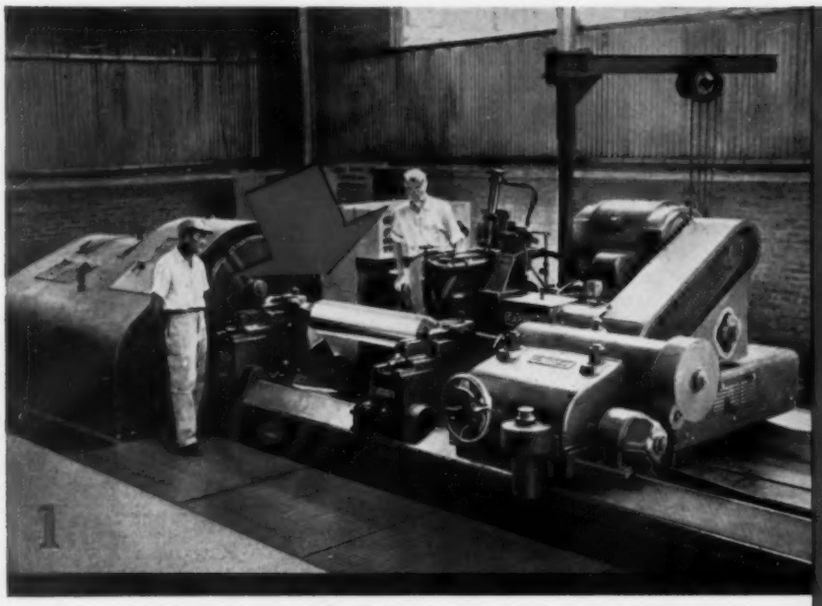

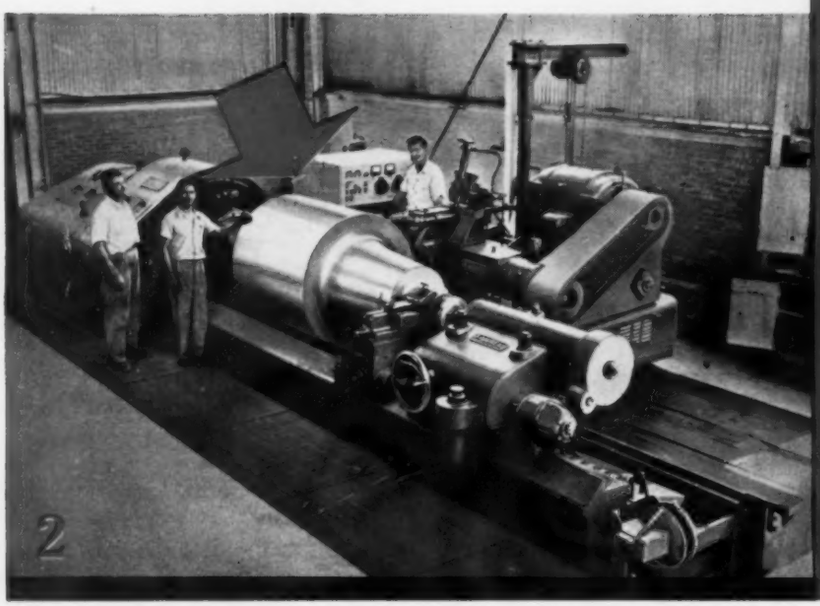

FARREL® ROLL GRINDER shows its versatility in Mexican steel mill

The above machine is a Farrel heavy duty roll grinder, size 44″ x 14′0″. It has shown its ability to grind rolls of widely varying dimensions and materials to any desired finish.

The small roll being ground in illustration No. 1 is a 10″ diameter work roll for a four-high mill which gives the skin or finishing pass to the metal. The large roll in No. 2 is a 46″ diameter backup roll for a four-high hot mill. This is two inches greater in diameter than the rated capacity of the machine.

The machine is owned by the steel mill of Hojalata Y Lamina and is in use at their Monterrey, Mexico, plant, located about 100 miles south of the Texas border. They say, " . . . the roll grinder has been doing excellent work. We are very glad we purchased it."

Farrel roll grinders are able to cut roll grinding time substantially and, at the same time, produce rolls with a perfect surface free from marks of any kind. The automatic crowning device produces a mathematically accurate curve, symmetrical on both halves of the roll, for either a convex or concave shape, without manipulation by the operator.

For more of the advantages of Farrel roll grinders, write for descriptive bulletin.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
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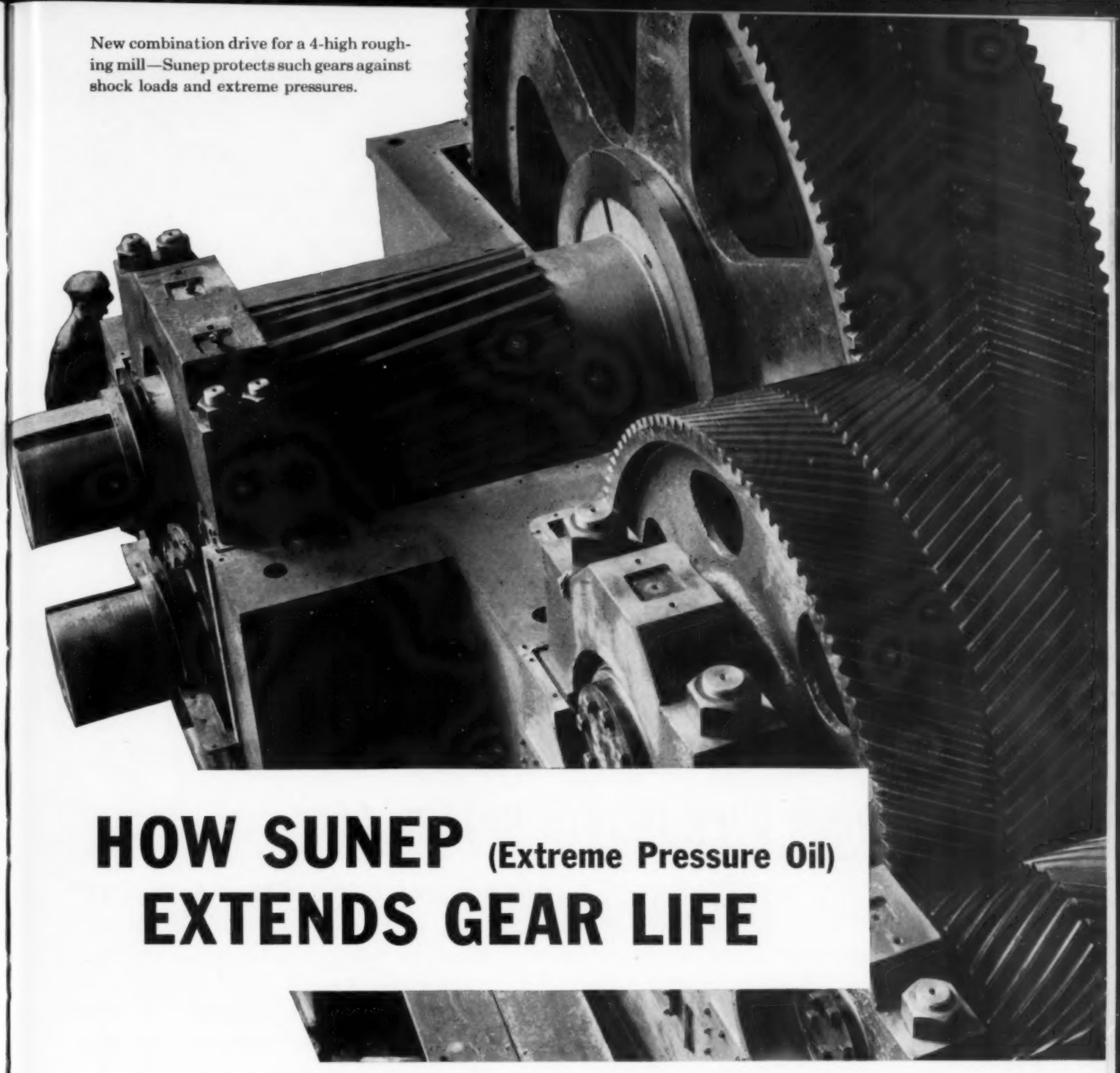
Farrel-Birmingham®



New combination drive for a 4-high roughing mill—Sunep protects such gears against shock loads and extreme pressures.

HOW SUNEP (Extreme Pressure Oil) EXTENDS GEAR LIFE

The advantage of running your machines at high speeds and under heavy loads can be quickly lost if your extreme pressure lubricants turn thick, lose film strength, or cause gears to corrode.

Sunep gives your gears better protection longer. Unlike many E.P. oils, Sunep is made from highly refined, premium grade oils skillfully blended with chemical additives that do not drop out during operation or in prolonged storage. This accounts for several rare user benefits: long life at extreme pressures; absence of corrosion—even on bronze; rust protection for steel parts; clean gears and bearings as a result of the oil's high stability.

Primarily a lubricant for enclosed gears, Sunep has proven to be highly effective on bearings and screws working under extreme pressures. Because of its exceptional clinging characteristics, Sunep guards against metal-to-metal contact during the early moments of machine operation after shutdown. FREE BULLETIN. Tells all about Sunep. Get your copy. Write Dept. IS-6.

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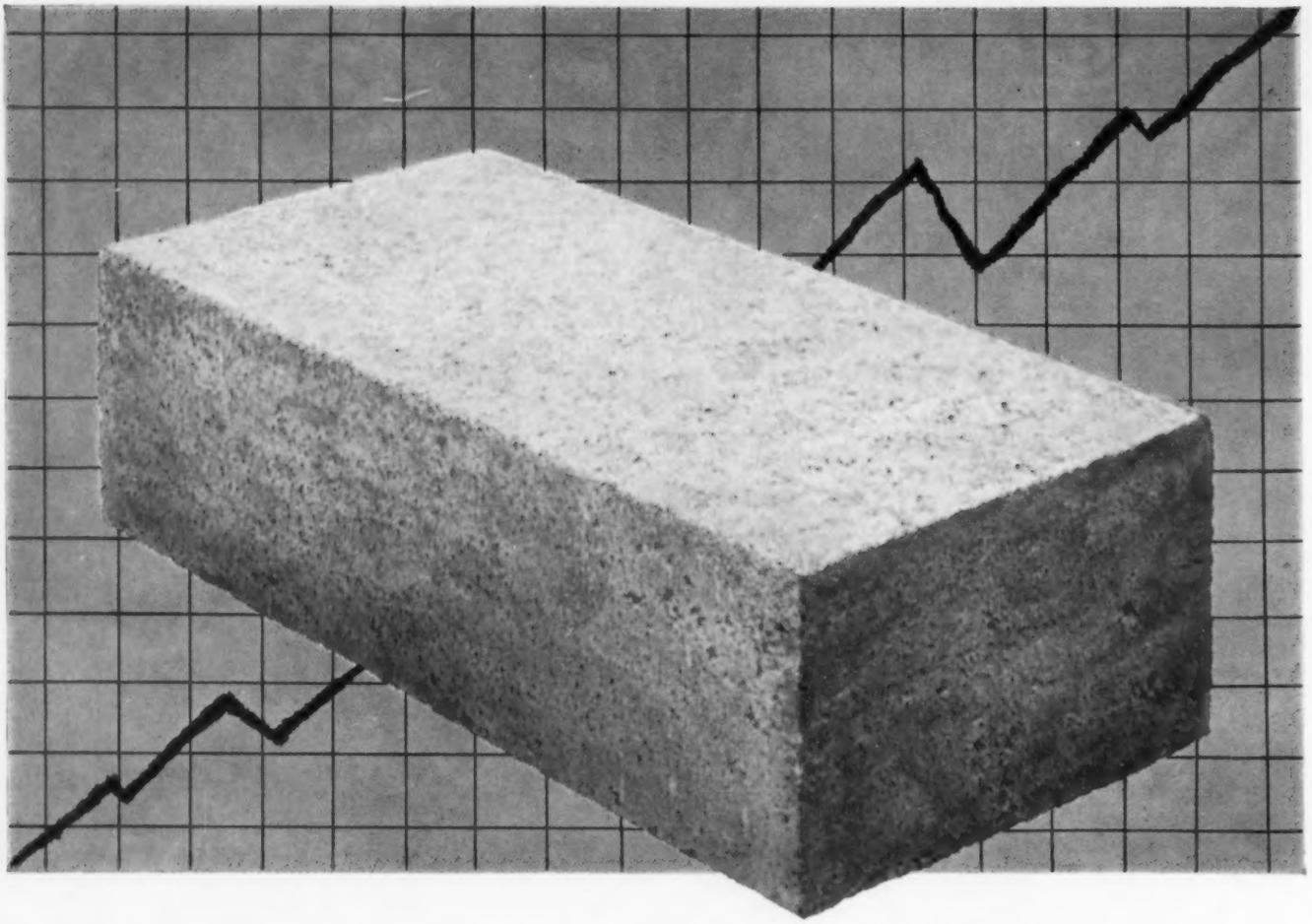

INCREASE YOUR OPEN HEARTH BOTTOM LIFE

WITH PERMANENTE PERICLASE BRICK!

WITH Permanente Periclase "D" burned brick as the subhearth under a Permanente 165 bottom you get *higher MgO per unit volume than possible with any other refractories available today.*

Permanente Periclase "D" bricks provide 9.43 lbs. of MgO per 9" equivalent, plus *maximum* density with absence of connected voids. Used in combination with Permanente 165 you are sure of the ultimate in bottom safety and durability.

Write for descriptive literature on (1) Permanente Refractory Brick, (2) Permanente 165, and (3) the companion ramming mix, Permanente 84.

Principal sales office: Chemical Division, Kaiser Aluminum & Chemical Sales, Inc., First National Tower, Akron 8, Ohio.

Permanente Periclase Brick for the Steel Industry:

PD-B (Periclase "D" burned) brick for open hearth and electric furnace bottoms. Low in iron, lime and silica. Chrome free. Maximum MgO in bottom.

PCA, PCA-MC (Periclase-Chrome "A"), plain and metal-encased for open hearth end walls, front walls and uptakes. Metal-encased for electric furnace sidewalls. High in MgO. Outstanding all-purpose refractory.

CPA-B (Chrome-Periclase"A," burned) for open hearth front and back walls. Controlled chrome additives result in highest resistance to spalling.

CPA-MC (Chrome-Periclase "A"), metal-encased for open hearth back walls, front walls. **D** (Chrome "D" burned) for open hearth bottoms, soaking pits. High hot load strength.

Installation advice on request

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Producers of the most complete line of basic refractories

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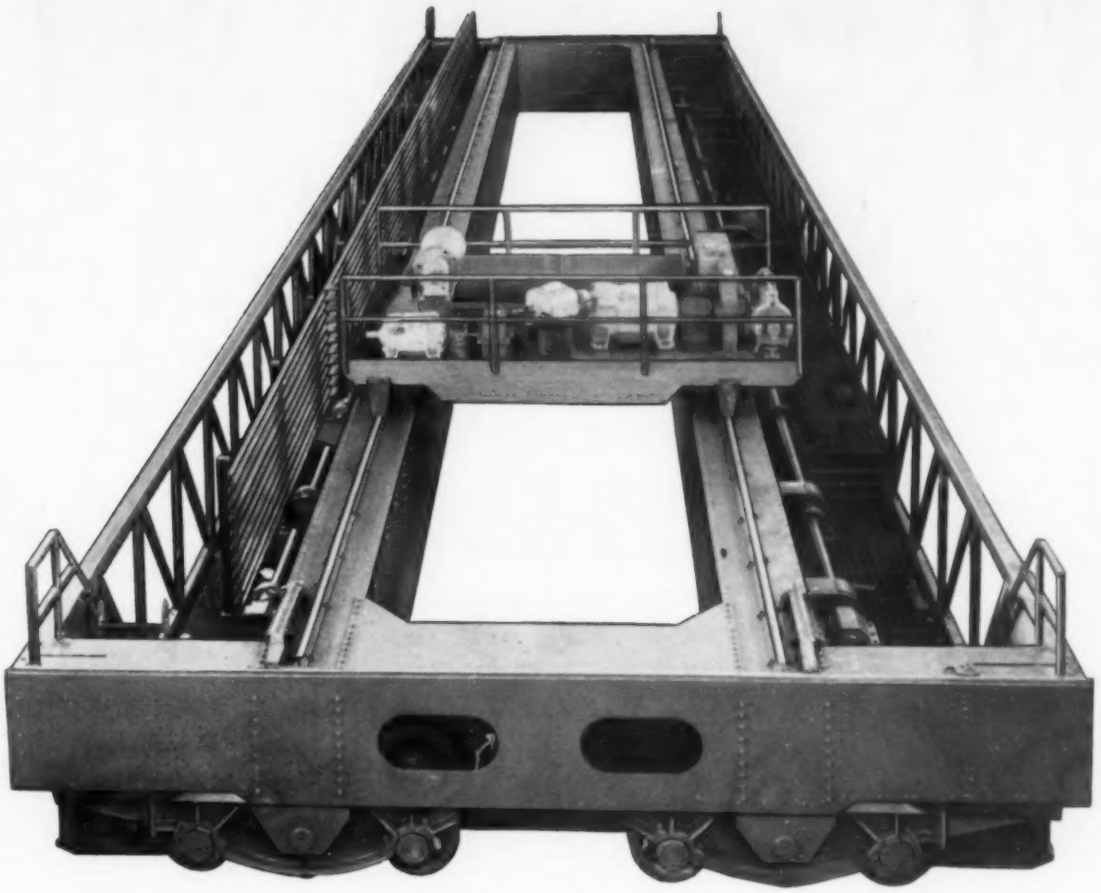

CRANES TO A.I.S.E. SPECIFICATIONS... by "Shaw-Box"

If your next cranes are to be built to A.I.S.E. specifications, you'll find your greatest value in "Shaw-Box" Cranes. Shaw-Box has standard designs and has already built many cranes up to and including 100-tons capacity to A.I.S.E. specifications. Typical of their interpretation of these specifications, is this 25-ton capacity, 100-foot span crane.

In "Shaw-Box" Cranes — whether built to an individual mill or to A.I.S.E. specifications — you get the added advantages that come from "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. These added advantages insure crane performance that make "Shaw-Box" Cranes — for the work they do — the least expensive cranes to buy and the most profitable to use.

BE SURE TO SEND ALL YOUR INQUIRIES FOR STEEL MILL CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX."

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' and 'American-Microsen' Industrial Instruments and Aircraft Products.

Ohio Rolls

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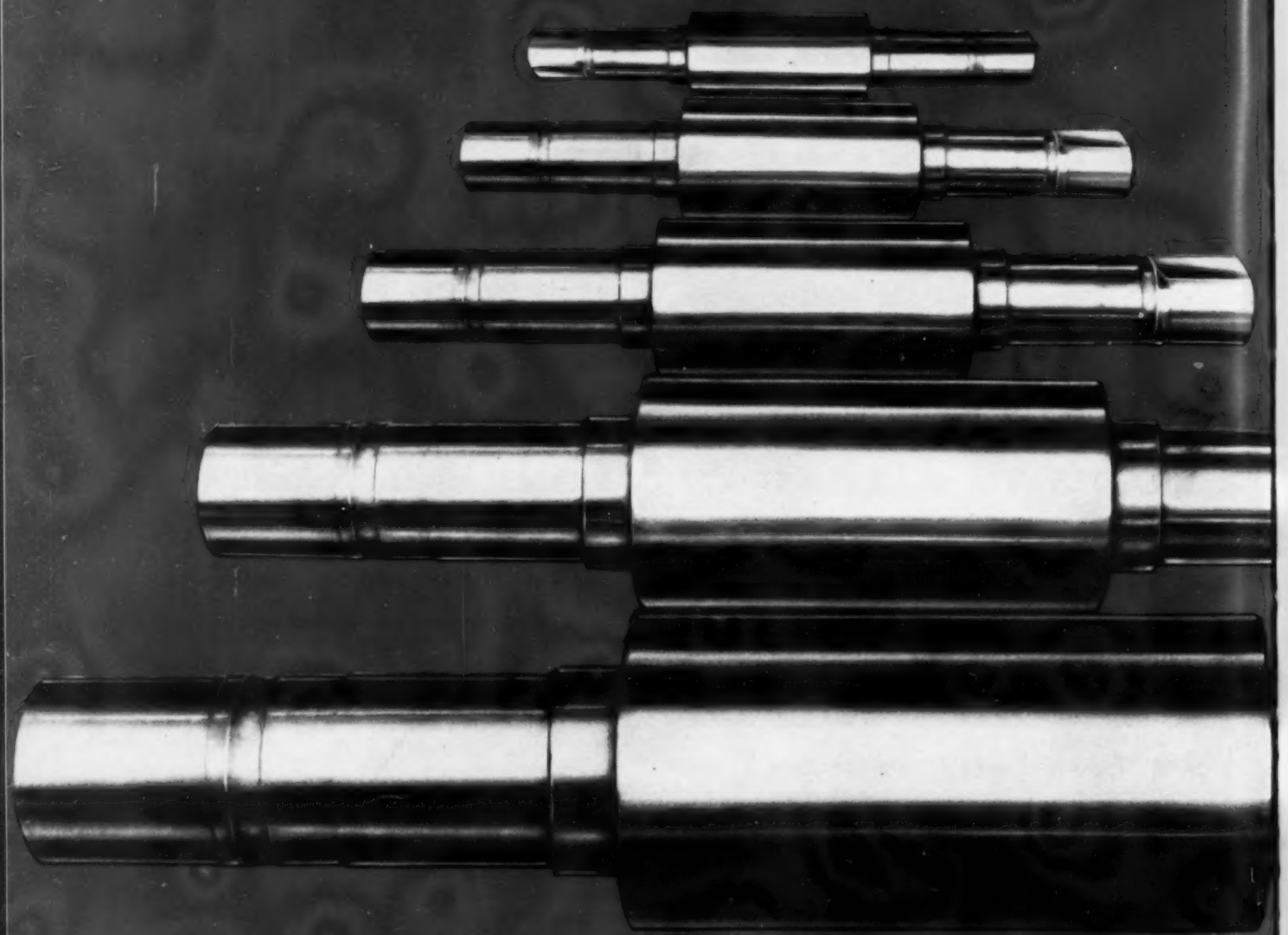

Choose from 11 Types of Ohio Iron and Steel Rolls

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Industry News...

KAISER ENGINEERS ACQUIRES U. S. RIGHTS TO LICENSE OXYGEN STEELMAKING PROCESS

▲ Exclusive rights in the United States for the European oxygen steelmaking process have been acquired by Kaiser engineers division of Henry J. Kaiser Co.

As sole United States licensor for Brassert Oxygen Technik A.G. of Zurich, Switzerland, Kaiser engineers joins the world-wide partnership of member firms which have developed this new approach to steelmaking. Combining the high tonnage, low cost features of the bessemer process with the high quality of the open hearth furnace, this new oxygen converter process promises to be one of the most important steelmaking advances in the last 50 years.

With three plants now operating in Europe on a commercial basis and one plant under construction in Canada, the oxygen process is demonstratively beyond the pilot plant stage and is an accepted addition to the art of making steel.

The process is relatively simple in principle, consisting essentially of blowing a jet of high purity oxygen upon the surface of a molten pig iron bath in a converter vessel. A wide range of pig iron analyses can be refined by this process and the quality of the resulting steel is as high and can be as closely controlled as in open hearth practice. Up to 25 per cent of the charge can be scrap metal.

Estimated production tonnages for each converter are two and one-half to three times higher per hour than the conventional open hearth furnace. The operating costs (exclusive of metallics and fixed charges) for each ton of steel produced is at least three dollars lower than similar costs for open hearth steel.

Current estimates place the capital cost of an oxygen converter shop at 50 per cent or less than a comparably sized open hearth shop, depending on size, location, available facilities, and other variable factors.

Brassert Oxygen Technik A.G. is a Swiss company organized for the development and dissemination of operating techniques and designs for world-wide use. Continental European firms who have and will contribute operating and design data are: Vereinigte Oesterreichische Eisen- und Stahlwerke A.G., Linz, Austria; Oesterreichische-Alpine Montangesellschaft A.G., Donawitz, Austria; Mannesmann Huettenwerke A.G., Huckingen, Duisburg, Germany; John Miles & Partners, Ltd., London, England; and H. A. Brassert & Co., Berlin-Charlottenburg, Germany. Dominion Foundry and Steel Co. of Hamilton, Ontario, Canada as sole Canadian licensor of Brassert Oxygen Technik A.G. is currently building a commercial plant which will be in operation later in 1954.

J & L TO OPTION ORE DEPOSIT FOR STUDY

▲ Jones & Laughlin Steel Corp. will option, for purposes of further tests and study, a large iron ore deposit six miles from Kirkland Lake, Ontario, Canada. Agreement has been reached with Gulf Oil Corp., which controls the property in which the ore range is located.

The option will permit J&L to explore the property for two years and further will provide for leasing the property by the steel corporation if the results of such exploration are encouraging.

The deposit is a magnetic taconite ore of Keewatin type, J&L geologists report. The iron-bearing rocks occur interbedded with greenstones. The tonnages and grades of the taconite are not definitely known, J&L geologists say, but it is expected that the property may contain a reserve of 150 million tons of crude open pit magnetic taconite ore.

During the two-year option period, the exploration and research program on the new ore site would be aimed at proving the grade, tonnage, and con-

SAFETY AWARDS HONOR THREE U. S. STEEL PLANTS

Three Chicago area steel plants of U. S. Steel Corp. received awards for outstanding safety records in 1953 at the 31st annual safety conference sponsored by Greater Chicago Safety Council. Accepting awards presented by Elmer S. Reske (left), vice president of the council, are John H. Vohr, general superintendent, Gary Steel works, John W. Cremer, supervisor-safety, Gary sheet and tin mill, and John L. MacKenzie, safety director, South Chicago works. Safety records set were: Gary Steel works, 1.15 lost time accidents per million man hours worked; Gary sheet and tin, 1.01; and South works, 1.87.

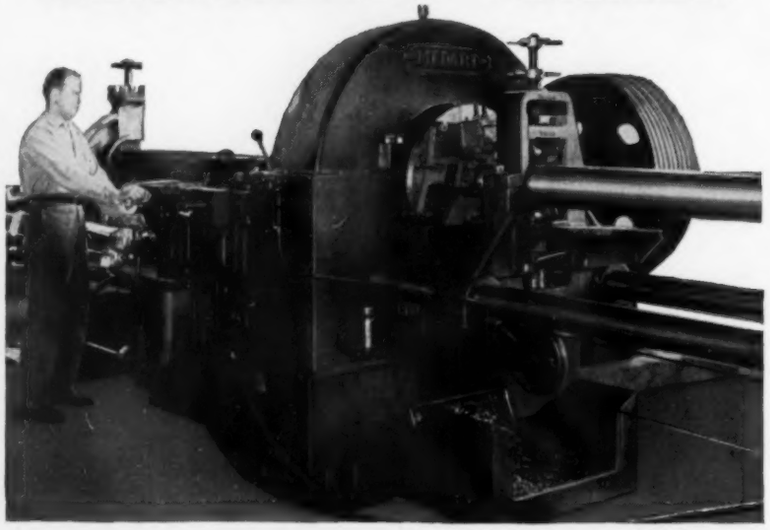
Automatic High-Speed Centerless Turning & Peeling!

. . . for bars and tubes from 1" to 10" diameter, and larger

MEDART

MODEL RFRG

CENTERLESS TURNER



- For high production superior finish, close-tolerance turning or rough peeling. Workpiece size and throughput speeds are limited only by capacity of cutting tools.
- New direct-drive roll-feed with patented Universal Centering Device insures continuous, positive feed and automatic centering of workpiece in cutterhead.
- Separate variable drives for feed and cutterhead give exact ratios between cutter speeds and bar feeds.
- Either 1 or 2 removable cutterheads may be used, with from 1 to 10 cutters for maximum cutting flexibility. Either carbide or high-speed tools are used.
- Eliminates time lost in loading and unloading. Automatic input and output grip carriages permit constant end-to-end feed and delivery.
- Fully automatic push button control from central operating station.

Write For Complete Details

Most Complete Source For Mechanical Drive Equipment

THE MEDART COMPANY 7535 DE KALB STREET ST. LOUIS 18, MO.

centrating characteristics of the ore.

Negotiations between J&L and the Gulf Oil Corp. for the Kirkland Lakes property have been under way for some time. The final agreement has been delayed pending the outcome of negotiations for the establishement of a competitive freight rate between the Canadian deposit and J&L's steel plants in the Pittsburgh district.

A competitive freight rate has now been reached through the cooperation of the Ontario Northland, Canadian National, New York Central, and Pittsburgh & Lake Erie railroads. All four will participate in the movement of the Kirkland Lakes ore to Pittsburgh. This all-rail shipment should make possible year-round operation of the property, in contrast to seasonal operations in the Lake Superior district.

COMPLETE TUBULAR EXPANSION PROGRAM

▲ Completion of an expansion program which will increase by nearly 40 per cent the productive capacity for stainless steel tubular products has been announced by the Tubular Products division of the Babcock & Wilcox Co.

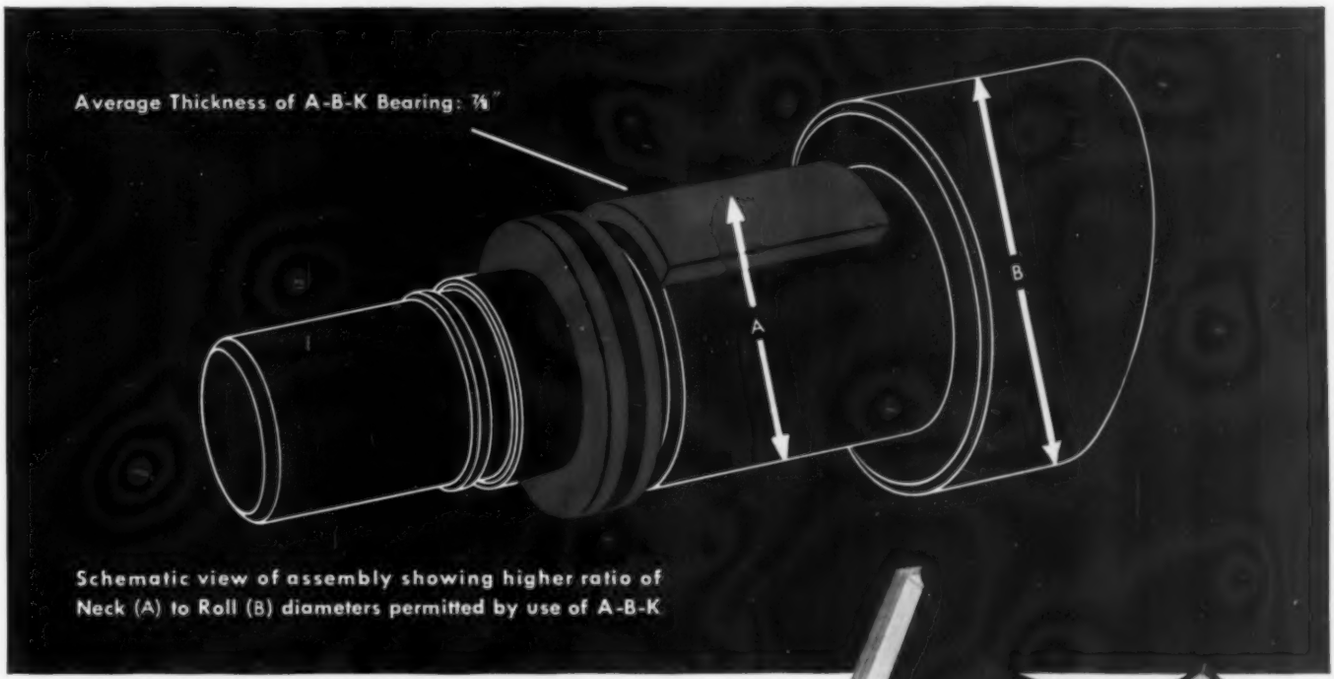
Rapid advancements in the atomic energy, aircraft and boiler industries not only have increased the need for stainless tubing of the standard grades, but also have established the need of special grades of stainless tubing having unusual strength properties under conditions of high temperature and stress.

In its tube manufacturing plants, the underlying theme of the program at B&W has been the integration and flexibility of facilities to meet the changing needs of industry. In other words, the equipment was arranged so that the plants can switch from making stainless to alloy, or vice versa, very quickly and thereby effect considerable savings in both time and money.

A highly important part of the program is the equipment for the hot extrusion of tubing. Principal advantage of this method, known as the Ugine-Sejournet process, is that metals such as molybdenum and certain stainless steels which are difficult or impossible to pierce by conventional methods, can be made into tubes by extrusion in less than five seconds.

In addition to the obvious advan-

A-B-K BEARINGS IN ENCLOSED DESIGN PERMIT LARGER NECK to ROLL RATIOS!



Schematic view of assembly showing higher ratio of Neck (A) to Roll (B) diameters permitted by use of A-B-K

A-B-K laminated fabric bearings save space! Permit the design of compact assemblies with larger and stronger roll necks . . . less expensive, lighter weight parts.

A-B-K bearings cushion impact loads, wear longer in many applications. These fabric bearings are simple to store, easy to handle. They reduce maintenance and replacement costs. Grease or oil can be used for lubrication but water *alone* is often the answer.

Our engineers will be glad to help you take advantage of A-B-K for new mill equipment or old. Write us about your applications today.

A-B-K®

LAMINATED FABRIC BEARINGS

AMERICAN Brake Shoe COMPANY

Copyright 1954, American Brake Shoe Company

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN
IN CANADA: JOSEPH ROBB & CO. LTD., MONTREAL, QUEBEC

PICKLING ACID INHIBITOR

RODINE®

Photo by courtesy of United States Steel Corporation, Fairless Hills, Pa.

"Rodine" more than pays for itself in savings of acid and metal. More uniform pickling and better pickled surfaces are obtained when "Rodine" is used in acid pickling baths.

When sheet steel is pickled continuously, "Rodine" improves the surface and prevents "pickle burning" in prolonged pickling.

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY
General Offices:
AMBLER, PENNSYLVANIA
Detroit, Mich. Niles, Calif. Windsor, Ont.

tage of speed, the process also makes it possible to produce steel tubing of many shapes and forms for a variety of uses. B&W recently announced that it has produced tubing with integral fins by extrusion.

INLAND STEEL STARTS ADDITIONAL FURNACE

▲ Inland Steel Co. blew in an additional blast furnace at its Indiana Harbor, Ind., plant. This lifted to seven the total furnaces in operation. The company has eight blast furnaces with a rated annual capacity of 2,638,950 tons of pig iron.

The number two furnace started up has been banked since February 13. It has an annual capacity of 266,450 tons.

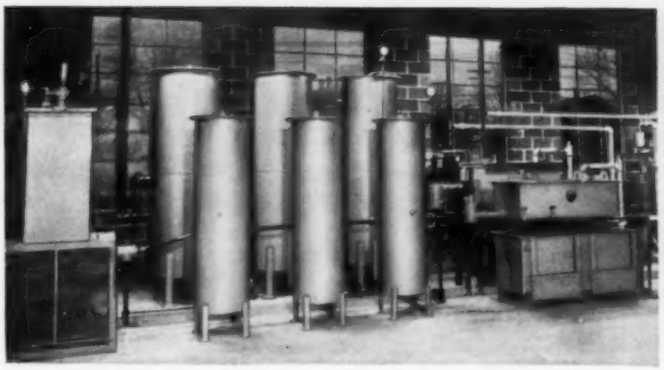
Hjalmar W. Johnson, vice president in charge of manufacturing, said the seventh furnace was added because the ratio of pig iron costs to scrap steel prices made it economical to increase the proportion of hot metal from the blast furnaces going into steelmaking and to cut down purchases of outside scrap.

ENGINEERS RECEIVE TRINKS HEATING AWARD

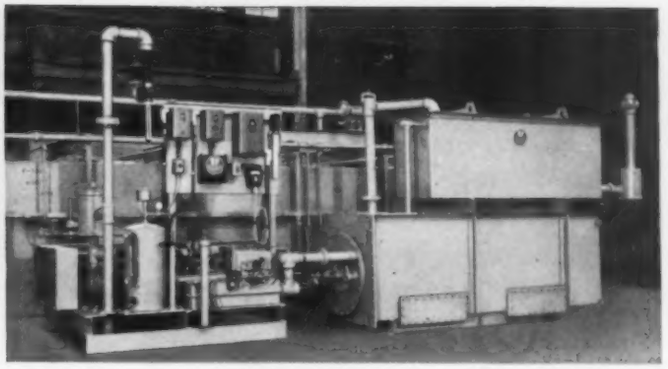
▲ Five men, who have made notable contributions to this country's economic or scientific progress in industrial heating, were recipients of the industry's top honor, the Trinks Industrial Heating Award, at a banquet sponsored by the award committee.

The five honored, all engineer-executives, were: William M. Hepburn, vice president in charge of engineering, Surface Combustion Corp.; Frederic O. Hess, president, Selas Corp. of America; Dr. Russell P. Huer, vice president in charge of research, General Refractories Co.; Matthew H. Mawhinney, consulting engineer from Salem, Ohio; and Lee Wilson, Lee Wilson Engineering Co., Inc.

The award is bestowed annually by a judge's panel of industrial heating authorities, among candidates nominated by the industry, for outstanding contributions to industrial heating science or economics. It was established in honor of Dr. Willibald Trinks, professor emeritus of Carnegie Institute of Technology, and world authority on industrial heating problems.



An EF installation consisting of a 1500 and a 3000 cfh exothermic horizontal water cooled type special atmosphere unit, each with desulphurizing towers and refrigerators for bright annealing steel and copper, and clean annealing brass.



An EF kerosene exothermic gas generator. These are also built in several sizes and types for producing special atmospheres for use in bright annealing copper and steel products in areas where fuel gases are not available.

EF SPECIAL ATMOSPHERE EQUIPMENT

For any Heat Treating Process . . . any Capacity

Long Experience = High Efficiency + Low Maintenance

Gas scrubbing units are available in several sizes and types for use with EF special atmosphere generating equipment where it may be necessary to remove CO_2 or H_2S.

● As pioneers in the development and use of equipment for producing low cost special atmospheres, we are in position to furnish a wide range of reliable, thoroughly tested special atmosphere units, including endothermic and exothermic gas generators, ammonia dissociators, refrigerators, dryers, desulphurizers, gas scrubbing units and other special atmosphere equipment — equipment with a reputation for high efficiency,— and low maintenance and operating costs.

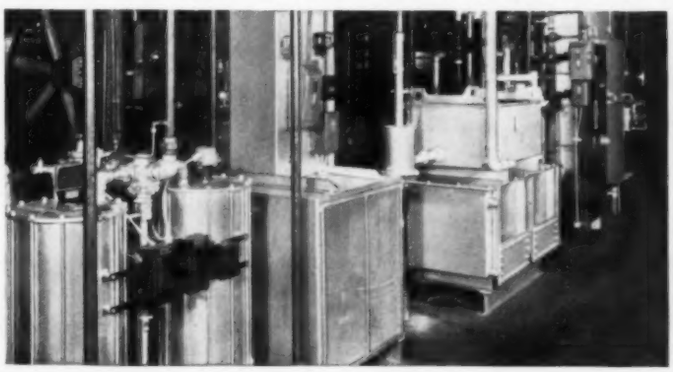
Submit your furnace or special atmosphere problems to experienced engineers — *IT PAYS*

EF Ammonia Dissociators are built in many sizes and types for producing highly reducing atmospheres as required for bright annealing stainless; and other annealing and normalizing processes and preventing decarburization.

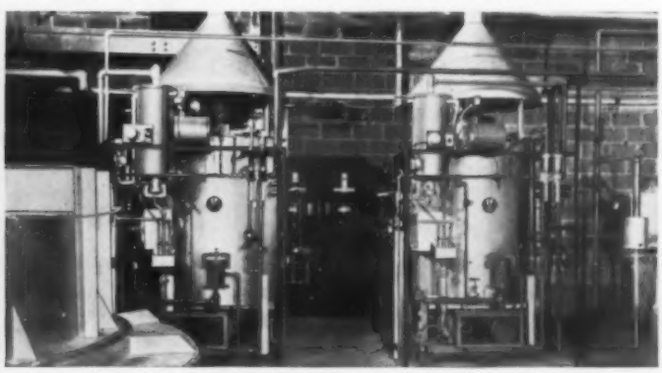
THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R.R. *Salem - Ohio*

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

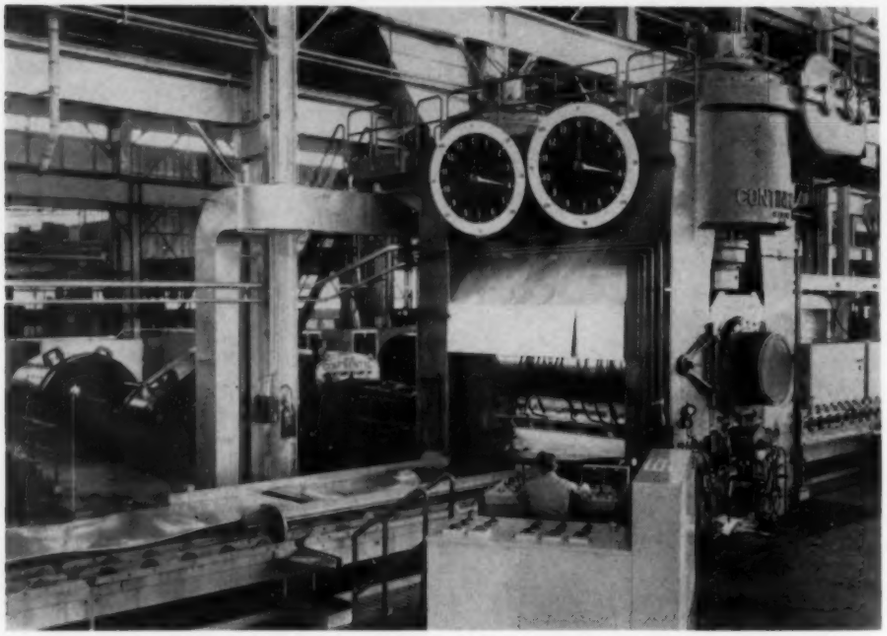


EF special atmosphere installation consisting of an exothermic generator, refrigerator and dryer as used with EF furnaces for bright and clean annealing ferrous and non-ferrous products.



An installation consisting of two small EF oil fired endothermic generators producing special atmospheres from propane for carburizing and other processes.

ALCOA ROLLING MILL OPERATING AT IOWA WORKS



This 144-in. tapered sheet and plate rolling mill has begun production at Aluminum Co. of America's Davenport, Iowa works. The big mill, which was supplied to Alcoa under lease from the U. S. Air Force, will produce tapered sheet and plate for the wing skins of giant aircraft such as the Boeing B-52.

Created by Frank Vittor, nationally famed sculptor, the award proper consists of a large gold-bronze medallion bearing Dr. Trinks' likeness.

Judges on this year's Award Committee were Dr. W. Trinks; Dr. John C. Warner, president, Carnegie Institute of Technology; T. J. Ess, managing director of the Association of Iron and Steel Engineers, and editor of *Iron and Steel Engineer;* Carl L. Ipsen, executive vice president of the Industrial Furnace Manufacturers Association; and Harold A. Strickland, vice president-engineering, Hotpoint Co.

WANTED!

PUMPING JOBS NOBODY ELSE WANTS!

You can buy lots of good pumps for ordinary pumping jobs, *but* NAGLE PUMPS are built to survive in those applications where ordinary pumps fail.

If you must pump highly abrasive mixtures, corrosive liquids, hot solutions or heavy slurries, then you will save by using NAGLE CENTRIFUGAL PUMPS. Engineered to your specific requirements—The right design, the right materials of construction. Horizontal and vertical shaft types in complete range of sizes. Send for Catalog 5206.

• Modified type "SW-O" vertical shaft pump built by Nagle for severe service in an atomic energy plant.

NAGLE PUMPS

NAGLE PUMPS, INC.
1263 CENTER AVE., CHICAGO HEIGHTS, ILL.

PUMPS FOR ABRASIVE AND CORROSIVE APPLICATIONS

PLANS MANUFACTURE OF PLASTIC PIPE

▲ National Tube Division of United States Steel Corp. will begin installation immediately of equipment for the manufacture of plastic pipe.

L. J. Mason, vice president of National Tube, said that the installation would be located at Gary works and actual extrusion of pipe would start sometime in September. Mr. Mason announced that screw-type extruders would be installed which would manufacture pipe from one-half in. to six in. Several plastic materials will be used, including polyethylene and polyvinyl chloride.

National Tube has been experimenting with a pilot plant manufacturing plastic pipe since late 1952 at McKeesport, Pa., and it was announced that additional development work will be continued on improved thermoplastic materials, as well as work on reinforced thermo-setting types of plastic.

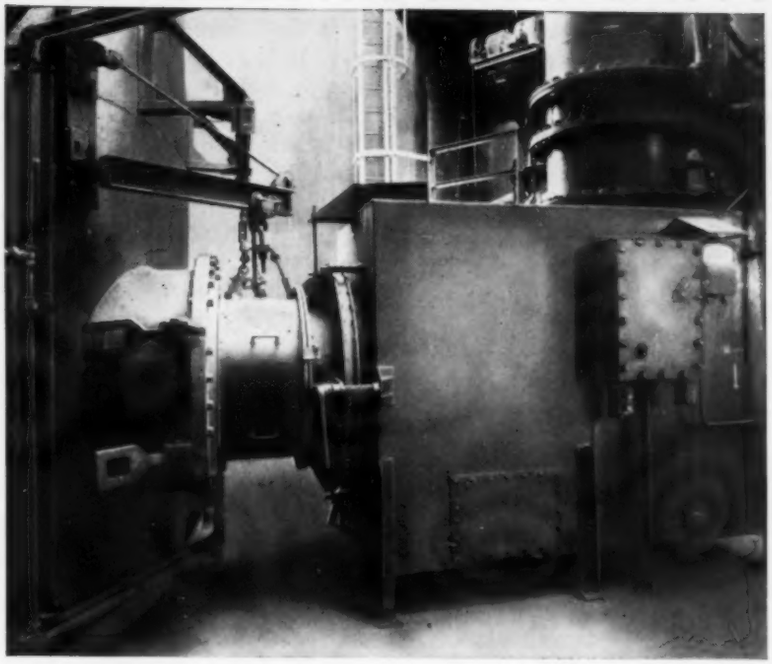
OPERATES SECOND GALVANIZING LINE

▲ A second continuous galvanizing line has been put into operation by Inland Steel Co., and the last of its old-style molten zinc "pots" has been retired.

Both of Inland's continuous lines will produce the company's Ti-Co brand galvanized sheets under the Sendzimir patent process. Addition of the second line will mean an increase of about 33 per cent in the company's galvanized sheet capacity and make possible production of about 200,000 tons per year.

FOXBORO BREAKS GROUND FOR WEST COAST PLANT

▲ Ground has been broken for a new branch factory to be erected in San Leandro, Calif., by the Foxboro Co.



The Accumulated Experience of

25 YEARS

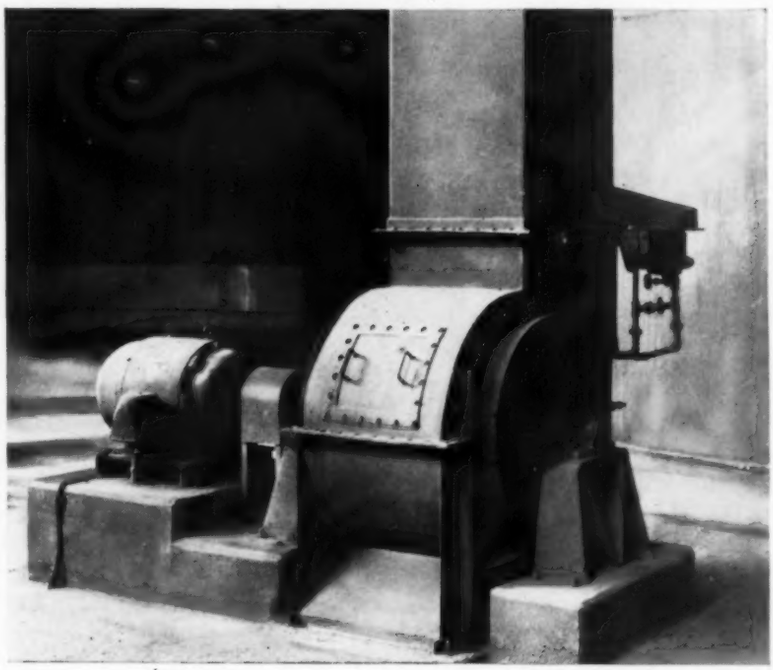
IN THE DESIGN, MANUFACTURE AND INSTALLATION OF OVER

500 UNITS

IS INCORPORATED IN THE

Freyn-Design

BLAST FURNACE STOVE BURNER



*

AVAILABLE IN CAPACITIES FROM 8,000 TO 25,000 CFM GAS

*

TWO-THIRDS OF SALES HAVE BEEN REPEAT ORDERS

KOPPERS

METALLURGICAL PLANT DESIGN AND CONSTRUCTION

KOPPERS COMPANY, INC.

Freyn Engineering Department

KOPPERS BUILDING • PITTSBURGH 19

Associated with Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND

Scheduled for completion by August 15, the new 8400 sq ft building will more than double the production area of the present San Francisco shop and provide increased facilities for the manufacture, sales and service of instruments and accessories.

Commenting on the new factory, B. H. Bristol, president of the company, pointed out that the West Coast move is part of a threefold expansion of Foxboro's nation-wide instrument production and service facilities to meet the growing demand for process instrumentation. A new Dallas factory, recently completed, will serve industries of the South and Southwest. In addition, a site has been selected and construction started for a new Pittsburgh factory to be completed in the near future.

ANNEALING FURNACE PUT INTO OPERATION

▲ A new annealing furnace and two additional furnace bases have been put in operation at the Warren, Ohio, plant of the Thomas Strip Division, Pittsburgh Steel Co.

The new Lee Wilson gas-fired radiant tube type circular furnace, which can be moved from base to base, is one of a battery of three modern portable furnaces. The three furnaces have a total of seven 88-in. diameter bases. The newest installation adds 1000 tons a month to the plant's annealing capacity and represents a $135,000 investment.

Each of the three large circular, portable furnace bases will hold three or four stacks of coils piled to a height of about 94 in. The average charge is 35 to 40 tons. The coils are heated in inert gas to prevent oxidation and produce bright annealed finishes.

The division also has a continuous normalizing line, three smaller furnaces with nine bases, two rectangular furnaces with eight bases, an all-electric circular furnace with three bases, 13 "in and out" coal-fired furnaces and two "in and out" gas-fired furnaces.

LICENSES COMPANY TO PRODUCE CASTINGS

▲ Waunakee Alloy Casting Corp., Waunakee, Wisc., has been licensed to produce "Trantinyl" special alloy steel castings by Youngstown Alloy Casting Corp.

The founder and president of Youngstown Alloy Casting Corp., J. Trantin, Jr., is majority stockholder and metallurgical consultant of the newly licensed Wisconsin plant.

INSTRUMENT FIRM PLANS NEW PLANT

▲ Construction of a modern instrument plant on a 129-acre tract adjacent to North Wales, Pa., approximately 22 miles from the heart of Philadelphia, is planned by Leeds & Northrup Co.

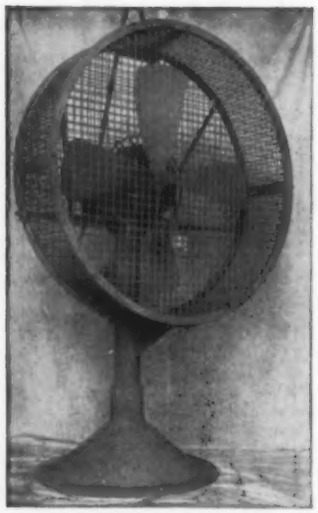
Present schedules call for construction to start in the early Fall, with occupancy in latter 1955. Approximately 1300 of the firm's 3100 employees will be at the new location.

The building will provide facilities for the manufacture of recorders and controllers, panels and cubicles for load frequency control, as well as space for supporting units engaged in engineering, industrial engineering, order control, inspection, receiving, warehousing and shipping.

IS HEAT SLOWING UP YOUR WORKMEN?

TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS



TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY

245 MAIN ST. HARMONY, PA.

Stearns circular lifting magnet carrying a 4,000-lb tank track.

How deep-ribbed cases protect

DEEP-DOWN
PULLING POWER

The cooler the magnet, the better its lifting efficiency. That's why powerful, deep-field Stearns lifting magnets are designed for maximum heat dissipation. In both the welded and bolted units, the heavily ribbed magnet case provides greater radiation area, for cooler and more efficient operation.

This design also provides greater protection against internal and external damage in the event of rough handling. These are important reasons why you can operate Stearns magnets profitably on steady, long-shift duty.

In addition to fast heat dissipation, Stearns magnets offer the following advantages:

- **Permanently sealed magnet coil not disturbed when servicing terminals or pole shoes.**
- **Leads and terminals fully protected against abrasion and shock.**
- **Vacuum-impregnated windings assure long life, and dependable operation.**
- **Waterproof construction.**

Stearns lifting magnets — both circular and rectangular are available in a wide range of standard sizes. Custom-built models on request. See your Stearns representative or write for Bulletin 35-B-2.

1092

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC. 681 S. 28th St., Milwaukee 46, Wis.

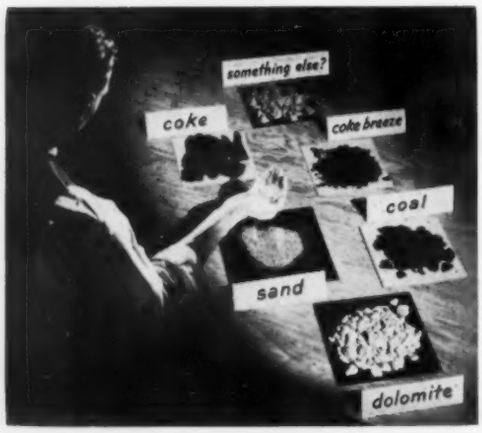
HERE'S ONE WAY TO HANDLE BULK-HANDLING-PROCESSING PROBLEMS

Call R&S

Tired of working late hours on knotty problems of bulk material handling?...or processing, storage, service? Take this ideal step one toward a simple, practical solution — just call R&S.

What you'll be doing is acquiring a staff of seasoned engineers who have been solving problems like these for over 50 years. They can start "from scratch," or pick up from your roughly sketched ideas; then make finished drawings, convert drawings into fabricated units, handle final erection — any part of the job or all of it.

What's your problem? Use this sensible approach: Call CEntral 6-7292 (Chicago) — Collect.



ROBERTS & SCHAEFER CO.

ENGINEERS AND CONTRACTORS

130 North Wells Street, Chicago 6, Ill.

HIBBING, MINN. (Box 675)
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PITTSBURGH 22, PA.

R&S AND COMPANY

Leeds & Northrup officials emphasize that the new plant will not replace the long-established headquarters at 4901 Stenton Ave., and other properties in the Germantown section of Philadelphia. The general offices, and the manufacture of heat-treating furnaces, laboratory equipment, and other lines of instruments will continue there.

ANNOUNCES OPENING OF WEST COAST UNIT

▲ Heppenstall Co., announces the opening of a new warehouse and office at 6440 Fleet St., Los Angeles 22, Calif. The company also has warehouses at Bridgeport, Conn., Pittsburgh, and Detroit.

The new warehouse will be operated under the management of W. P. Wooldridge Co., west coast agent for Heppenstall Co.

TO DESIGN FURNACES FOR PIPE ANNEALING

▲ Rust Furnace Co. will design and construct two new heat treating furnaces for pipe annealing for Jones and Laughlin Steel Corp. at its Aliquippa works.

Now in design, the furnaces, of the continuous walking beam type, will serve the Aliquippa works' new seamless tube specialties department. They will be 54 ft 9 in. wide by 45½ ft long with a six-ft height in the heating zone and four-ft height in the soaking zone. Coke oven gas will be used as fuel with natural gas as a standby.

REPUBLIC TO PURCHASE CHAIN ORGANIZATION

▲ Agreement for the purchase of property and assets of Cleveland Chain and Manufacturing Co., and its affiliated companies was announced by Republic Steel Corp.

The agreement provides that Republic will purchase the inventory, fixed assets, and business of the chain companies for cash and common stock of Republic Steel and that the sale will be consummated sometime prior to July 15, after completion of necessary legal details. The agreement of sale was reached after extended negotiation between officials of Republic and representatives of the chain companies.

In announcing this proposed acquisition, C. M. White, president of Republic, pointed out that the various manufacturing plants of the chain organization constitute substantial consumers of steel.

COMPARE these Scarfing Rings used in the tip of a Gas Torch . . .

KENTANIUM Ring after 1,960 HOURS

SUPER-ALLOY Ring after 162 HOURS

There's no sign of wear on the Kentanium ring and it's still on the job . . . after 1,960 hours (80 days) of service! Compare this performance with that of the super-alloy ring that had broken down from thermal shock, abrasion, and oxidation after only 162 hours . . . a better than TEN to ONE record in favor of Kentanium. This is a typical example of how industry is effectively using heat-resistant Kentanium.

What's Your HOT Design Problem?

If you need a material having long service life at elevated temperatures, investigate Kentanium . . . an exclusive development by Kennametal. It is a titanium carbide base composition.

Kentanium resists thermal and physical shock, withstands abrasion and oxidation, and retains great strength at 1800°F and above. It weighs only ⅔ as much as steel; is up to 93 RA in hardness.

Many grades of Kentanium are available to meet combinations of specific conditions. A wide variety of simple or complex shapes can be produced, to meet your specifications. Ask our engineers to recommend how you can best apply this remarkable, new heat-resistant material.

An Exclusive Development of KENNAMETAL® Inc., Latrobe, Pa.

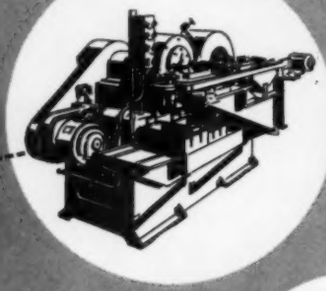
KENTANIUM

HEAT-RESISTANT, HIGH-STRENGTH, LIGHTWEIGHT CEMENTED TITANIUM CARBIDE

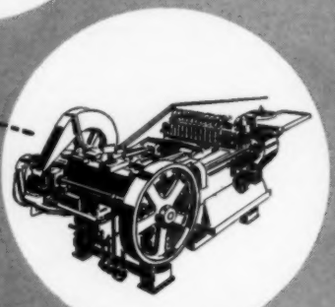
3-43

SALES OFFICES IN PRINCIPAL CITIES

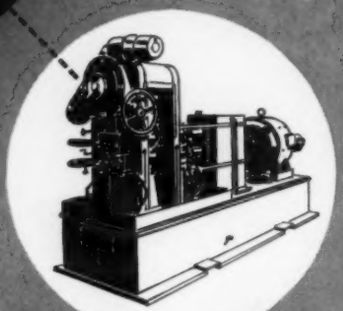
5 KINDS OF WATERBURY FARREL ANSWERS TO YOUR MASS PRODUCTION PROBLEMS



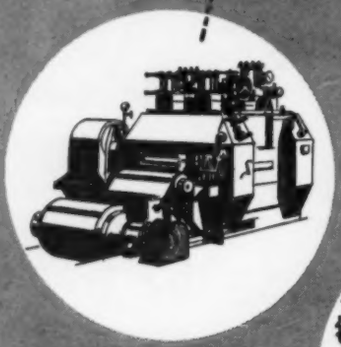
COLD PROCESS BOLT & NUT MACHINERY — Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc.



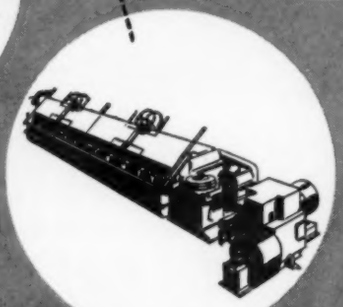
POWER PRESSES—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines • Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.



MILL MACHINERY — Rolling Mills: Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc.



SPECIAL MACHINERY — Sendzimir Mills • Small Arm Ammunition Machines • Collapsible Tube Machines • Coining Mills, etc.



WIRE MILL EQUIPMENT — Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers • Swagers • Bull Blocks • String-up • Machines • Spoolers, etc.

Within These Basic WF Equipment Lines, Individual Machines Are Custom-Engineered For Specific Applications

If your metal-working machinery problem falls into any of these five groups, there are good reasons for looking to Waterbury Farrel for the answer.

There's Waterbury Farrel's continuing engineering research with more than a century of machine building experience to draw upon. This results in soundly designed and thoroughly tested features which improve production.

There's Waterbury Farrel's world-wide reputation for rugged, long-lasting construction. This gives you the assurance that WF machines are built to provide long years of uninterrupted production.

Waterbury Farrel can custom-engineer special equipment or adapt a standard machine to fit your specific problem.

For further information, write for free booklets on any of the machines mentioned on this page or contact your nearest WF office.

HERE'S A SAMPLE of Waterbury-Farrel mass production equipment in action. This complete WF automatic production unit combines a 40-ton double-acting, upright blanking and cupping press, a conveyor feed and four 7-station horizontal drawing presses to draw 340 zinc shells per minute.

FOUNDED WATERBURY FARREL 1851

WATERBURY FARREL FOUNDRY & MACHINE CO. • WATERBURY, CONN.

Offices: Chicago, Cleveland and Millburn, N. J.

WF 7A

Total employment of the affiliated businesses to be acquired by Republic is about 1000 persons. Building floor space of the various manufacturing plants and warehouses approximates 450,000 sq ft. Largest of the organization's manufacturing plants is that of Cleveland Chain and Manufacturing in Cleveland.

Acquisition of the businesses will bring to Republic chainmaking experience extending back nearly 300 years. The organization was started in the United States by the Round family in 1870. Before coming to this country, the family had been engaged in chainmaking in England for more than 200 years.

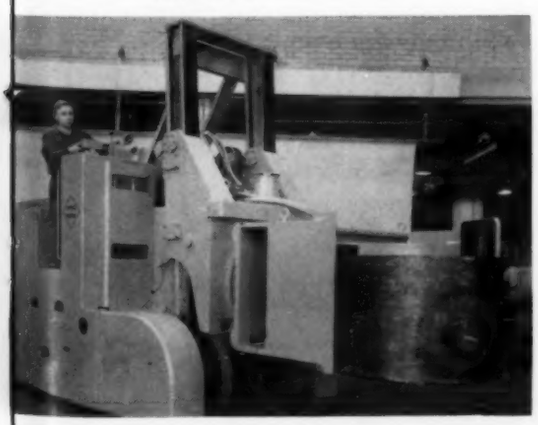
"This proposed acquisition is another step in Republic's diversification program," Mr. White said. "Chain is a natural supplement to many other lines of our manufacturing divisions and sale of such products fits our over-all sales pattern."

GE PLANS HEATING PLANT IN INDIANA

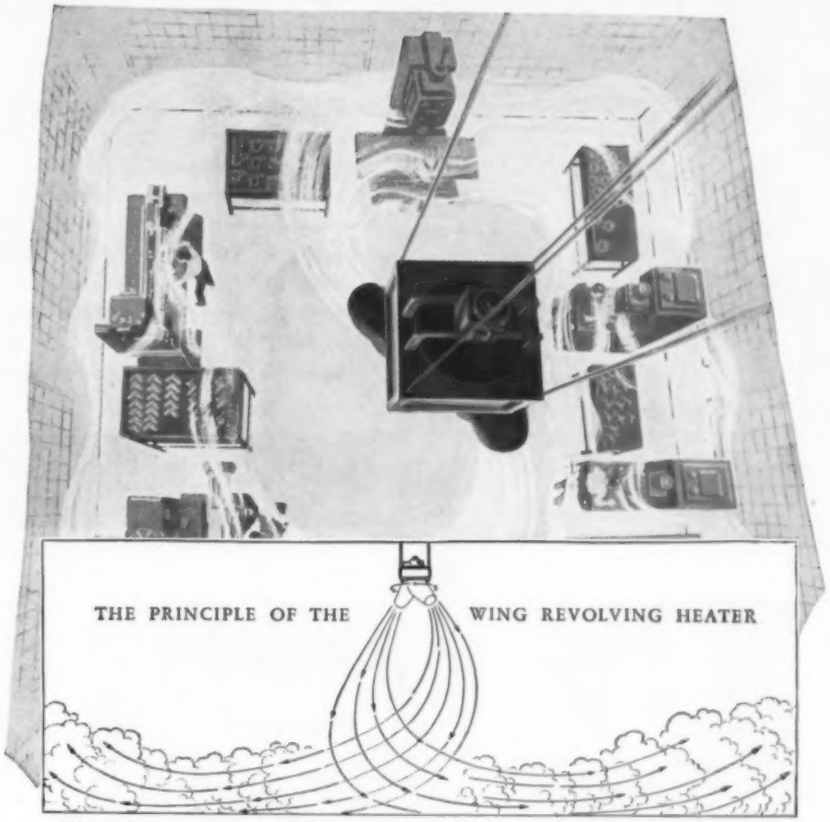
▲ General Electric Co. will begin construction this year of a new $5,000,000 plant at Shelbyville, Ind., to manufacture industrial furnaces, induction heating equipment, and heating devices.

COIL LIFTER AT GARY

Designed to increase handling flexibility, this industrial truck, equipped with a newly-designed rotating coil clamp which permits picking up 15,000-lb coils, was developed by Elwell-Parker Electric Co. for the Gary sheet and tin mill of U. S. Steel Corp. It permits lifting coils up to 56 in. in diameter. Minimum coil diameter is 32 in. A dual hydraulic pressure system with automatic pressure pick-up in the clamp circuit prevents accidentally dropping rolls through pressure drop. The clamp permits picking up coils in either the horizontal or vertical position and rotating them to the opposite position as required.



Summer or Winter . . . Wing Revolving Unit Heaters Bring Comfort to Your Employees . . .



The moving streams of heated air (or cooling breezes in summer) sweep slowly around through 360 degrees, covering successively every direction. The air velocity is sufficient to carry to walls, and remote corners and the constantly changing direction of flow causes the air to find its way around obstructions.

The slowly revolving outlets of the Wing Revolving Unit Heaters keep the air in constant, gentle motion, whether it be heated air in the winter or (with the steam turned off) the cooling breezes in the summer. In either case the effect on the worker is stimulating and pleasant. That is why plants equipped with Wing Revolving Heaters are satisfied *productive* plants. Why not investigate—today?

L. J. Wing Mfg. Co.

142 Vreeland Mills Road
Linden, New Jersey
Factories at Linden, N.J. & Montreal, Can.
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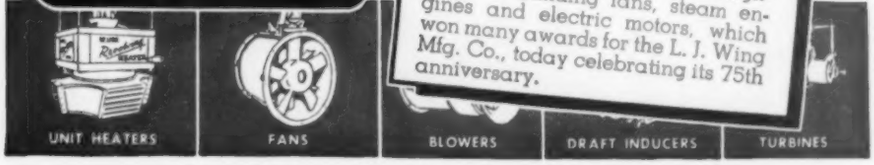
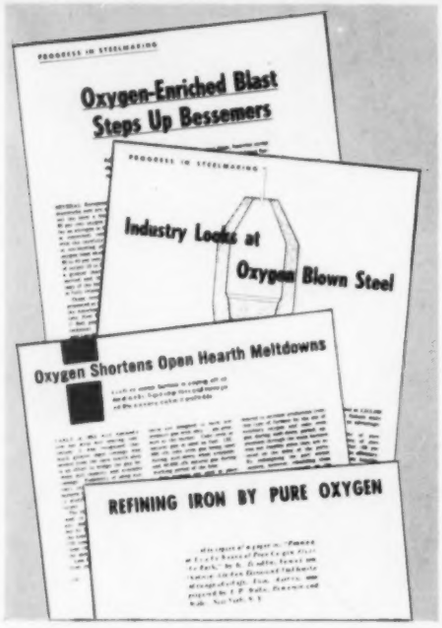
OUR 75TH YEAR 1879
Wing

SEVENTY-FIVE YEARS AGO

Demonstrating the new Edison phonograph. This simple hand-cranked machine, invented in 1877, was soon to be in every home, doing for sound what the invention of printing had done for literature. In 1879, L. J. Wing, another talented inventor of that period, was designing and building fans, steam engines and electric motors, which won many awards for the L. J. Wing Mfg. Co., today celebrating its 75th anniversary.

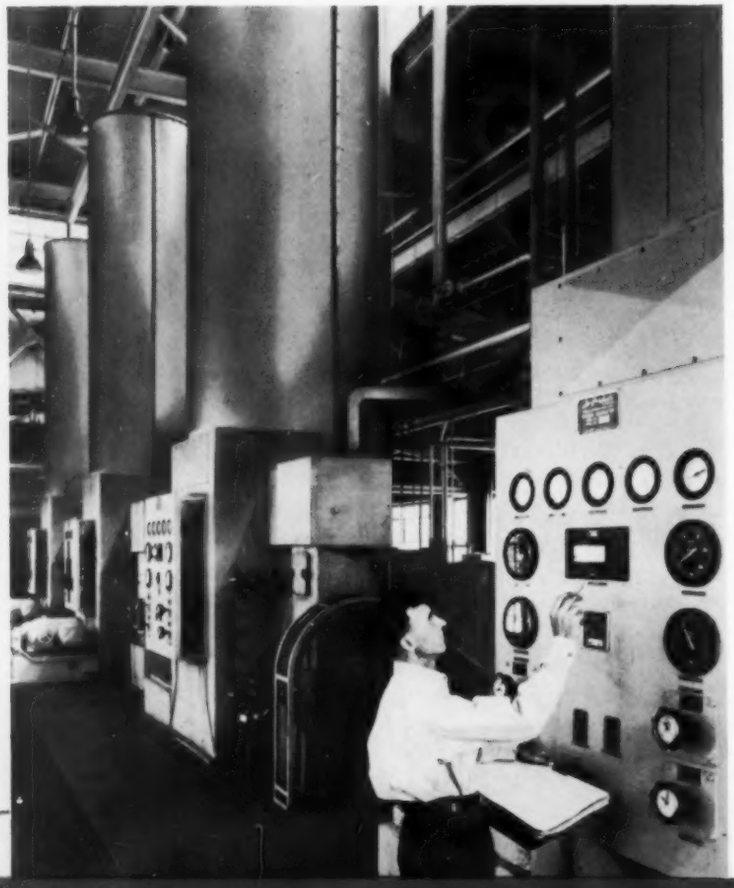



Oxygen-Enriched Blast Steps Up Bessemers
Industry Looks at Oxygen Blown Steel
Oxygen Shortens Open Hearth Meltdowns
REFINING IRON BY PURE OXYGEN

Prepare for Progress in
OXYGEN STEELMAKING

The growing use of oxygen in steelmaking for top blast conversion . . . flame enrichment . . . desiliconizing . . . hot-top heating . . . promises that you may soon need a source of dirt-cheap oxygen in tremendous quantities—100, 200, 300—even as much as 1000 tons per day. The only answer to this need is a *tonnage* oxygen generator, operated by you at your plant.

Be ready for the step to TONNAGE OXYGEN



To prepare for the big step to "tonnage" oxygen . . . *and* save thousands of dollars every year on existing oxygen requirements at the same time . . . lease an *Air Products* "Package" Oxygen Generator Installation *now*. You will learn the simple facts of making your own oxygen . . . get a substantial amount of *surplus capacity* oxygen that you can use to improve technology thru large-scale experiments . . . learn the latest techniques of oxygen steelmaking as they are developed.

It's easy to take the step to a "Package" Generator Installation. You make no capital investment for the generating equipment. Lease payments are 100% tax deductible. If your requirements change, individual generators can be added or replaced. If you need inert gas now or in the future, the generators can be adapted to also produce high-purity *nitrogen*. Anyone who can run an air compressor can run the equipment, and preventive maintenance is available on a scheduled basis.

Let us talk it over with you. Air Products, Incorporated, Dept. P., Box 538, Allentown, Pa.

...Take this step TODAY to *Air Products* INCORPORATED "Package" Oxygen Generators

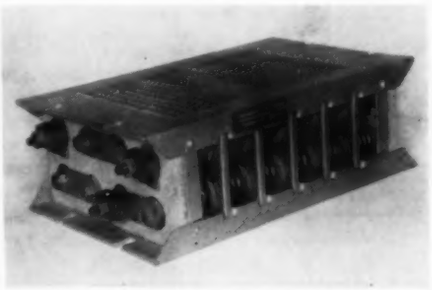
GUYAN
RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—R. E. Parry Co., 130 W. Chippewa St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—H. V. Varney Co., 625 Engineers Bldg.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—J. E. Brash, 18 W. Chelten Ave.

Pittsburgh 27, Pa.—P. R. Holden, 1602 Parkline Drive.

GUYAN MACHINERY COMPANY
LOGAN, W. VA.

When completed in 1955, the new plant will accommodate manufacturing operations now located at Schenectady and Pittsfield, Mass. It will be located on a 50-acre site, two miles east of the downtown area of Shelbyville.

Construction of the new plant is expected to begin in September of this year, with actual production getting under way sometime in 1956.

Designed to utilize the latest equipment for fabricating, welding, machining, assembling, shipping, and material handling, the Shelbyville installation will include a two-story office structure fronting a one-story manufacturing area with 170,000 sq ft of factory floor space. The entire area of the plant will total nearly 250,000 sq ft.

SIX FURNACES TO BE INSTALLED BY TIMKEN

▲ Timken Roller Bearing Co., has announced plans to install six new furnaces costing $360,000 and auxiliary equipment in the company's Bucyrus plant. The new furnaces, scheduled for installation by December 1, 1954, will carburize, harden and temper bearing parts at a capacity rate of 4300 pieces per hour.

Purchased from, and installed by, the Surface Combustion Corp., the new furnaces will process bearing parts coming from five bearing cone production lines. Already on order and scheduled for installation by December 1 are 16 automatic screw machines. The new screw machines will also be a part of the new cone production line.

A total of over three and one-half million dollars has been spent, and will be spent, within the next six months in the Timken Roller Bearing Co. expansion program at its Bucyrus plant.

COMPLETES EXPANSION AT CARMET DIV. WORKS

▲ Completion of an expansion and improvement program at its Carmet Division plant in Ferndale, Mich., has been announced by Allegheny Ludlum Corp. The new facilities make the company an integrated prime producer of cemented carbides for tool and die applications.

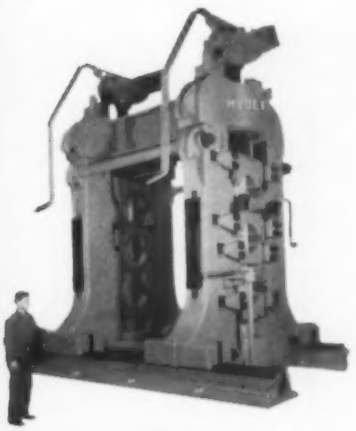
Floor space at the plant has been increased by 100 per cent and the company for the first time is manufacturing all its carbide powder in its own modern plant. In addition to the

Hyde Park

RED CIRCLE Rolls ALLOY-CHILLED

Rolling Mill Equipment

Outstanding in quality and in performance Hyde Park Rolling Mill Equipment has enjoyed the respect of the industry for more than fifty years.



Bar Mills
Merchant Mills
Sheet and Strip Mills
Pinion Stands
Roller Tables
Reduction Drives
Stretcher Levellers
Guillotine Shears
Sheet Mill Shears
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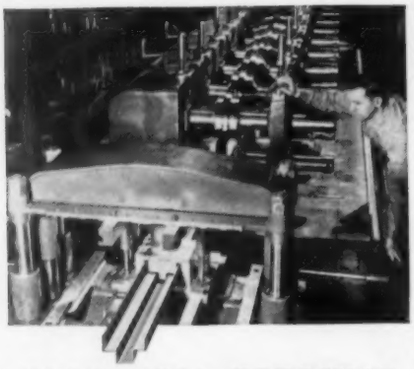
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS



COLD-ROLL-FORMING

• fastest,
• simplest,
most economical

In the assembly of your products, to the wide extent that cold-roll-formed components can be used, substantial economies can be effected.

A Yoder Cold-Roll-Forming Machine with one operator and a helper will make upwards of 30,000 feet per day. Thus the cost usually is only a small fraction of a cent per foot for converting strip into structural shapes, trim, mouldings, panels, tubular or box shapes.

The machine may, therefore, be highly profitable even if operated only a few days per month. After you install it for a given purpose, you are likely to discover other things which can be done better and more cheaply on it than by methods heretofore employed.

You may also find it practical to combine other operations with cold-forming, such as curving, coiling, embossing, welding, perforating, notching, etc., at little or no extra labor cost. Yoder engineers are always glad to assist in making up such multi-function production lines.

The Yoder Book on Cold-Roll-Forming is a valuable source of information on the scope, mechanics and economics of the art. Send for free copy.

THE YODER COMPANY
5495 Walworth Ave., Cleveland 2, Ohio

Cold-Roll FORMING MACHINES

ENGINEERING YODER MANUFACTURING

construction of the powder plant, the total capacity of the division has been increased by 50 per cent.

Operation of a more completely integrated plant will offer more flexibility in the research and development of different carbide materials. Allegheny Ludlum has been producing cemented carbides since 1943, when it purchased Carbide Alloys as a complement to its full line of tool and die steels. The facilities were moved to Ferndale in 1944. The Carmet Division produces a full line of tools, blanks, die sections, drawing dies and special shapes and parts of carbide metals.

BLAST FURNACE RECORD SET AT WARREN PLANT

▲ The Warren, Ohio plant of Republic Steel Corp. set a new monthly blast furnace production record in May.

The furnace produced 53,743 tons of pig iron during the month, an average daily output of 1734 tons. Its rated capacity is 1470 tons a day. Previous monthly record of the Warren furnace was established in October, 1953, when 51,306 tons of iron were made for a daily average of 1655 tons.

This is the furnace that set an all-time Republic annual production record in 1953 of 574,028 tons for a daily average of 1573 tons.

K. G. LeViseur is superintendent of the blast furnace department and R. M. Hadcock is assistant.

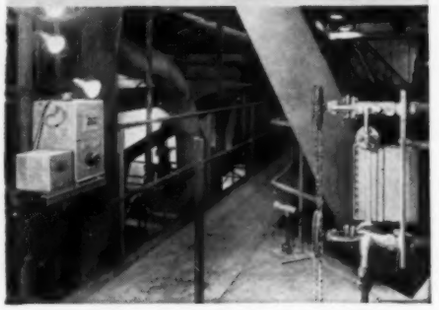
ACQUIRES ELECTRICAL FIRM AS SUBSIDIARY

▲ I-T-E Circuit Breaker Co. announces that through an exchange of common stock, the Bull Dog Electric Products Co. of Detroit, Mich., has become a subsidiary of I-T-E Bull Dog will continue to operate under its own corporate name, with William H. Frank remaining as president, and retaining the same personnel and policies. William H. and Henry B. Frank of Bull Dog will shortly join the board of directors of I-T-E.

I-T-E manufactures high and low voltage electric power distribution apparatus and special metal products. Bull Dog manufactures a line of non-competitive and complementary electrical equipment. The present sales and marketing methods of I-T-E and Bull Dog will be continued.

NOW You Can *See* Where You Can't *Look*

5 YEARS of CONTINUOUS OPERATION PROVE Dependability OF DIAMOND "UTILISCOPE"
(WIRED TELEVISION)



"UTILISCOPE" *camera at drum elevation SEES actual boiler water level.*

In 1948, Tidd Plant of Ohio Power Company (subsidiary of The American Gas & Electric Company) installed a Diamond "Utiliscope" so that the operator at the control panel could SEE the boiler water gauge several floors above. The camera location (adjacent to the big boiler drum) is hot and dusty. Auxiliary machinery causes vibration. The installation (including the original camera tube) has been in continuous use . . . 24 hours a day . . . 7 days a week for over 5 years, with very little maintenance. This is the first system of industrial television purchased in the U.S. and is still in continuous operation.

Probably there are places in your plant where you can use the DEPENDABLE "Utiliscope" (wired television) . . . the great new industrial aid. It is saving money and improving operations in steel mills, power plants, foundries, coal mines, and a wide variety of manufacturing plants. Use the coupon below.

"Utiliscope" Receiver

"Utiliscope" Camera

6702

SEND TODAY

DIAMOND POWER SPECIALTY CORP.
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Please send me without obligation a copy of new Bulletin No. 1136 showing how the Diamond "Utiliscope" (Wired Television) is being used to cut costs, improve operations and promote safety.

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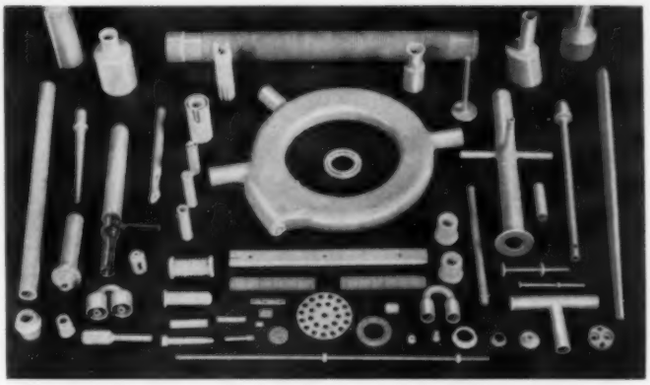
FIRST IN INDUSTRIAL TELEVISION
LANCASTER, OHIO
OFFICES IN 39 PRINCIPAL CITIES
Diamond Specialty Limited—Windsor, Ontario
SINCE 1903, DIAMOND HAS MANUFACTURED QUALITY EQUIPMENT FOR INDUSTRY



HIGH TEMPERATURE PORCELAIN SPECIALTIES

We are equipped to design and manufacture special porcelain products to do specific jobs. A few of the various shapes and sizes are shown above. On any of your porcelain requirements, a call to McDanel will save time and money.

Write today for our new catalog.

McDANEL Industrial PORCELAINS

McDANEL REFRACTORY PORCELAIN CO.
BEAVER FALLS, PENNA.

GRINDING BALL...MILL LINING BRICK...
MILL HEAD ASSEMBLIES...TANK & DRYER LININGS

"Luminum Line" ®
PIPE AND PLATE MARKER

Easier and more efficient to use because of its light weight . . . it is custom made to accommodate any number of stamps you require. A new steel reinforcing plate at the top reduces damage to the holder from misgauged hammer blows. Standard Safety Hevi-Bevl stamps can be used.

Write for Data Sheets

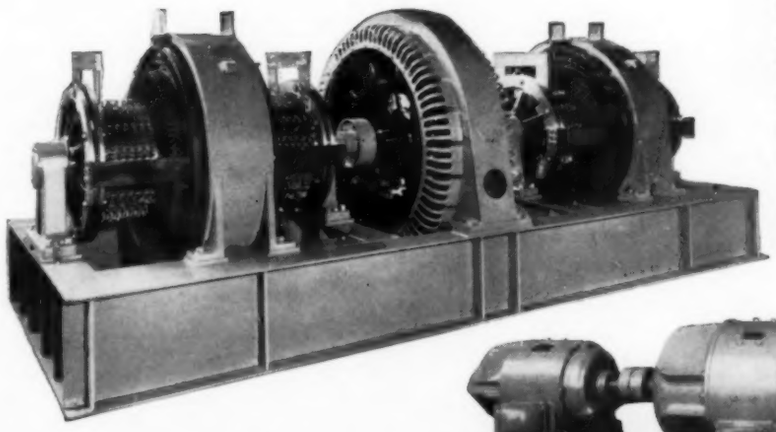
Mecco SAFETY MARKING TOOLS

M.E.CUNNINGHAM CO.
1041 CHATEAU STREET, PITTSBURGH 33, PA.

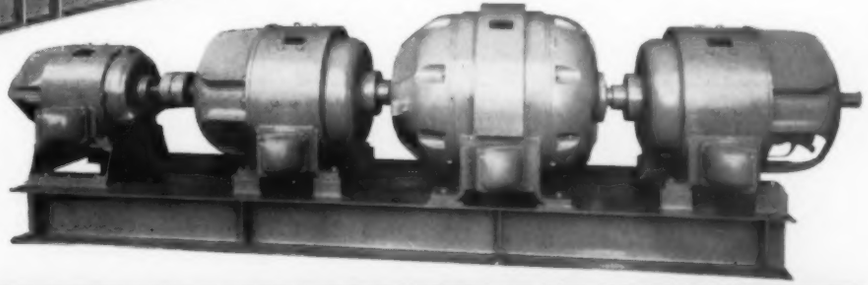
COLUMBIA

MOTOR GENERATORS

Whether it be for continuous electrolytic tinplating or electrocleaning lines, or for special power needs, Columbia builds Motor Generator Sets for your individual requirements. They're giving superior, around-the-clock performance in many of the country's leading mills. Illustrated here are typical installations of Columbia generators built to specification.



Two 7500 Ampere 24 volt, 3750 Ampere 48 volt, Separately Excited, Columbia D.C. Generators driven by 600 HP, 1.OPF, 360 RPM Synchronous Motor.



Multi-Unit Columbia Motor Generator Set consisting of two 50 KW, 250 Volt, D. C. Generators, and one 10 KW, 50 Volt, 200 Ampere booster Generator, all driven by 200 HP, 0.8PF, 1200 RPM Synchronous Motor.

COLUMBIA ELECTRIC MFG. COMPANY
4543 Hamilton Avenue — Cleveland 14, Ohio

Powder-Cutting Saves $2,000

This 3-ton, 13-in. thick magnesium-bronze flywheel casting was reduced to furnace-charging size by powder-cutting in less than 8 hours. Previous methods required over 16 hr. to cut up a casting only 4-in. thick. Powder-cutting proved to be the most economical method for this job.

Powder-cutting replaced cold-sawing in this foundry operation, and did three times the cutting in half the time.

LINDE engineers were called in to help solve the problem of reducing giant flywheel castings to furnace-charging size. The castings had been part of an experimental program to develop accurately balanced flywheels for diesel engines. Test castings had to be cut for remelting. . . . But because of their great size, scrapping by formerly used methods would have been costly—if possible at all. LINDE advised powder-cutting.

In powder-cutting, a powdered metal is added to the oxygen stream to raise the temperature of the cutting flame, and increase the speed of the severing action. Among other things foundries are using powder-cutting to remove gates and risers from stainless steel castings, to wash away sand-incrusted casting surfaces, and for gouging out defects prior to repair welding.

LINDE service engineers will be glad to help you determine the best powder-cutting setups or other uses of the oxy-acetylene process for your needs.

LINDE AIR PRODUCTS COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
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Division of Union Carbide Canada Limited

Linde Trade-Mark

"Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Personnel News...

Joel Hunter was elected president of Crucible Steel Co., succeeding **William H. Colvin.** Mr. Colvin will continue as a member of the executive committee and board of directors. Mr. Hunter joined Crucible in 1951 as vice president in charge of finance and was elected a director of the company and executive vice president in 1953.

Paul Carnahan, senior vice president of Great Lakes Steel Corp., has been elected president of that company. Mr. Carnahan became affiliated with Great Lakes Steel in 1934 and has served in an executive capacity in various positions in the operating and sales departments. **James A. Henry,** vice president of National Steel Corp and vice president in charge of sales of Weirton Steel Co., has been elected vice president and director of sales of National Steel Corp. **Wilmer A. Murphy,** executive vice president of Weirton Steel Co. has been elected vice president and director of purchases and raw materials of National Steel Corp. **Lee D. Brueckel,** vice president in charge of export sales, has been elected to succeed Mr. Henry as vice president in charge of sales of Weirton Steel Co.

James M. Darbaker was appointed senior vice president of Copperweld Steel Co. He also has been elected a member of the board of directors. Widely known in the steel industry, Mr. Darbaker has held various important administrative, production and sales positions with the United States Steel Corp. for 34 years. He was general superintendent of the sheet and tin mills of Carnegie-Illinois Steel at Gary and Ellwood, Ind. Later, Mr. Darbaker was made manager of operations in the Chicago District. In 1949, he was transferred to Pittsburgh and advanced to general manager of sales. From this position, he was promoted in 1952 to director of distribution and availability for the United States Steel Corp.

Thomas J. McLoughlin, assistant to vice president, operations — steel, United States Steel Corp. has retired. He started at Duquesne Works of U. S. Steel under a student training program in 1913. Later he served as an open hearth superintendent, a metallurgist, a superintendent of fuel and power department. In 1936 he was made assistant to the manager of operations for the Pittsburgh District, and he was named assistant to the vice president in charge of operations in 1937. He was appointed to his present position in 1950.

E. G. Fenton was appointed vice president in charge of operations of Empire Steel Corp. He joined Empire in 1951 as assistant to the president, and was named works manager in 1953.

H. A. Denny was appointed vice president and assistant general manager of the engineering and construction division of Koppers Co., Inc. Also named to new posts were **A. B. Fisher, Jr.,** who will be general superintendent of construction, **George P. Wilson** who will be production manager, and **Richard W. Vollmer,** who will assume the responsibilities of manager of the chemical and gas department of the engineering and construction division.

V. H. Lawrence, vice president — planning and control, of Jones & Laughlin Steel Corp. was named vice president — industrial relations. He succeeds **W. R. Elliot** who has retired.

John E. McCauley, president of Birdsboro Steel Foundry and Machine Co. for the past 20 years, was elected chairman of the board and chief executive officer. **G. Clymer Brooke** was promoted from executive vice president to president. **James M. Heppenstall** was advanced from treasurer to vice president and treasurer, and **Arlan L. Wentzel,** former assistant vice president and works manager, was made vice president and works manager. Two other officers were elected to the same positions they previously held: **Edward T. Peterson,** vice president engineering, and **Lester E. Leinbach,** secretary.

Nelson C. George, assistant chief metallurgist at Gary sheet and tin mill of United States Steel Corp. has been promoted to chief metallurgist. He succeeds **John A. Eckel,** who has been promoted to assistant to the general superintendent at U. S. Steel's Fairless Works in Morrisville, Pa. Mr. George started with Gary in 1936 as a laboratory technician. He was promoted to

JOEL HUNTER

PAUL CARNAHAN

JAMES M. DARBAKER

THOMAS J. McLOUGHLI

assistant metallurgist in 1937, and in 1938 became general supervisor in the tin division. In 1953 he was promoted to assistant chief metallurgist.

W. W. Hopwood was elected president of The Hagan Corp. He succeeds **David J. Erikson** who has retired. Mr. Hopwood, son of the company's founder, has

W. W. HOPWOOD

been a vice president and director of the firm since 1949. Mr. Erikson, who will serve as a consultant, joined the company in 1915 and helped establish the company's New York office in 1920. He became sales manager in

DAVID J. ERIKSON

1927, vice president in 1939, and president in 1948. On his election to the presidency in 1948, he succeeded **John M. Hopwood,** the company founder, and the only man to pre-date him in service with the company.

Harry K. Taylor was named assistant vice president in charge of operations for Jessop Steel Co. Mr. Taylor joined the company in 1944 in the composite steel division. During the past year he has been assistant to the vice president in charge of operations. Before joining Jessop, Mr. Taylor was employed by Lukens Steel Co.

M. J. Boho, vice president in charge of sales for Hagan Corp., has been named general manager of the corporation and of all its subsidiaries. These include Hall Laboratories, Inc., Calgon, Inc. and the Buromin Co. Mr. Boho became assistant general manager of sales in 1942 and vice president in charge of sales in 1948.

J. W. Marrinan has been appointed assistant general manager of operations for Superior Steel Corp. Mr. Marrinan is a veteran of nearly 40 years in the steel industry. He started with the National Tube Co., and later joined A. M. Byers Co. where he served as a vice president and director.

William L. Blundell who has been connected with The Tata Iron and Steel Co., Ltd., in Jamshedpur, India, since 1914 has recently retired and has returned to the United States. Before going to India he was connected with the Gary Steel Plant of the Illinois Steel Co. and since 1942 was superintendent of blast furnaces of the Tata Iron and Steel Co.

Robert W. Marvin was appointed assistant general manager of the engineering works division of Dravo Corp. Mr. Marvin has been with Dravo since 1927.

ROBERT W. MARVIN

He has held several supervisory positions, his most recent having been operations manager of the same division.

Selden E. Doughty has been appointed production manager of the Carpenter Steel Co. alloy tube division in Union, N. J. He is now responsible for the division's production, engineering, scheduling and personnel. Before his appointment, Mr. Doughty was chief metallurgist at the mill.

Arthur E. Engstrom has been appointed manager of the production and order department of Republic Steel Corp. Cleveland district. **Edward J. Healy, Jr.,** was appointed assistant manager of the department for the strip mill. A veteran of 36 years service with the company, Mr. Engstrom had been assistant manager of the department. He joined Interstate Iron & Steel Co. in Chicago in 1918 and advanced through various positions to charge of the mill order department. When that company joined Republic Steel in 1930, he became secretary to the district manager in Chicago. In 1939 he was transferred to the general offices of the company in Cleveland and two years later was named chief bar

TAYCO-40 High Temperature Silica Cement is used at Fairless Works and other leading steel mills to obtain tight, weld-like joints in open hearth furnace roofs. Spalling is retarded; joint penetration by fluxes and iron oxide vapor is prevented.

Easy to use, smooth-working TAYCO-40 remains plastic *longer* when applied to porous silica brick, allowing ample time for proper laying and fitting. Less cement is used; thinner, tighter joints are obtained.

TAYCO-40 has a softening point nearly equal to the best grades of silica brick, and will *not* run out of joints at open hearth temperatures. Use TAYCO-40 for your furnace rebuilds and for hot repairs. Properties and service data are given in Bulletin 507. Write for your copy.

For an easier, better masonry job, use TAYCO-40. When mixed with water to the proper proportions, TAYCO-40 can be dipped, poured or trowelled.

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REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
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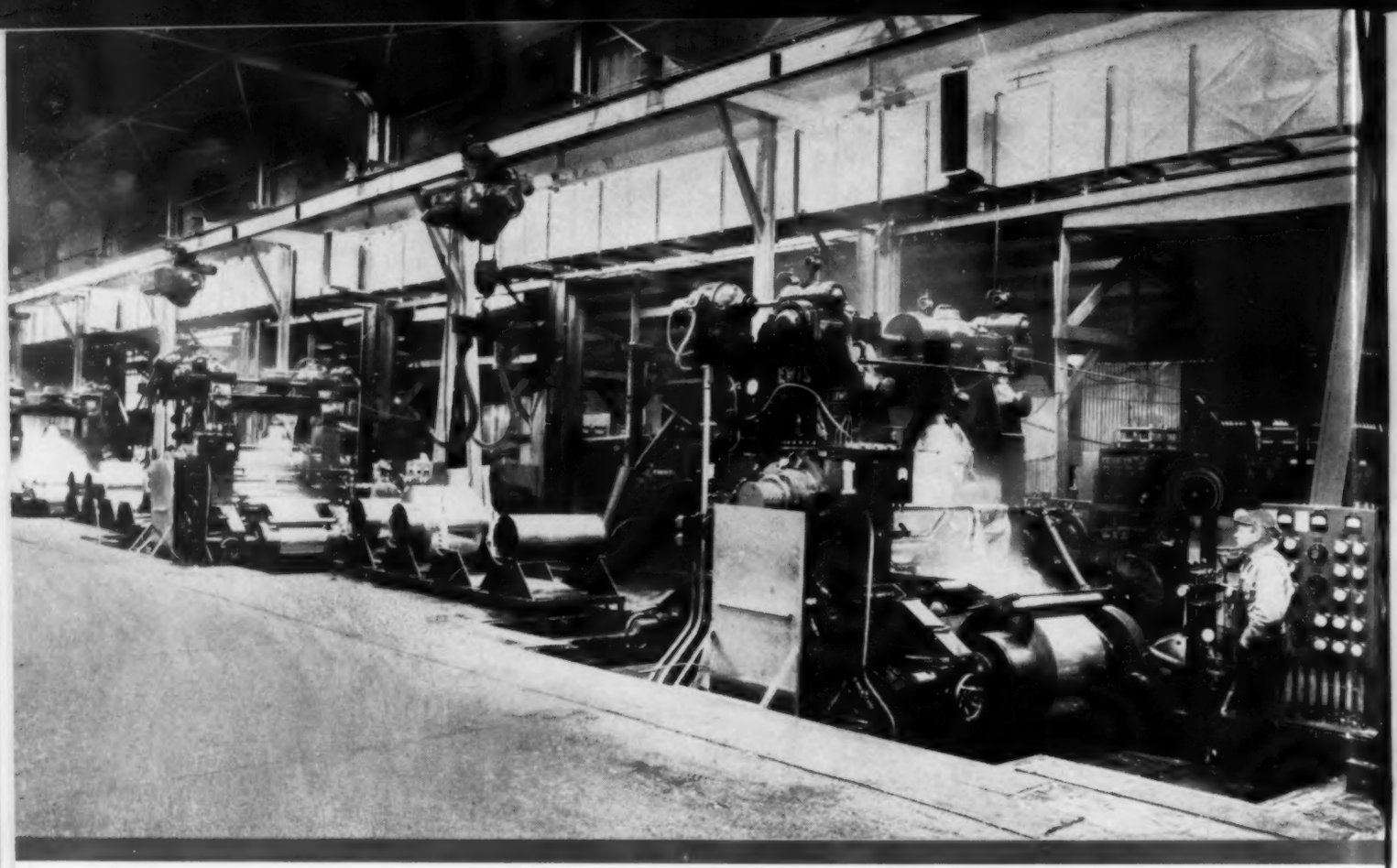

. . . will roll foil from .00035"
at speeds up to 4000 fpm
depending upon gauge thickness

To roll out thin sheets of aluminum at speeds up to 4000 feet per minute has taxed the ingenuity of the finest rolling mill engineers. But there are now over one hundred modern Lewis Foil Mills in operation, such as the 9" and 21" x 44" units shown in the illustration.

These mills generally start with .030" or .026" sheet . . . and for standard gauge foil reduce it to .00035" . . . at speeds ranging from 1000 to 4000 feet per minute.

Built in various sizes and widths to meet individual customer's requirements, these Lewis Foil Mills include the latest design in bearings, electric tension control and thermal control.

The thermal control is the key to successful operation and high production in foil rolling. It permits rolling of very thin metal at lower maximum tension and the production of full coils, evenly balanced in tension . . . which reduces breakage to a minimum. Coils from 3000 to 3500 pounds are being rolled.

Most of the mills are used for rolling aluminum foil, but they are equally adaptable for rolling all metals of light gauges. So if you have a problem in rolling thin metals, we'll be glad to give you complete information on the design and specifications of Lewis four-high Foil Mills . . . which can be built to your requirements.

In fact, if you have any problem involving rolling mill machinery, our experienced engineers and modern manufacturing facilities are always available.

LEWIS four-high FOIL MILL

BLAW-KNOX

BLAW-KNOX COMPANY • LEWIS MACHINERY DIVISION
PITTSBURGH 22, PENNSYLVANIA

LEWIS PRODUCTS: Two-High Mills • Three-High Mills • Four-High Mills • Bar, Billet and Structural Mills
Rod Mills • Coilers • Tables • Shears • Levelers • Pinion Stands • Gear Drives • Roll Lathes • Flaking Mills

mill scheduler at the steel plant. Subsequently he advanced to supervisor, production control, and assistant manager of the production and order department. Mr. Healy joined Republic in the accounting department at the strip mill in 1939. He advanced to supervisor of production control in 1950.

Dr. Robert P. Petersen, a nuclear physicist, has joined Republic Steel Corp. Dr. Petersen, who is chief of the industrial and production reactors branch, division of reactor development of the Atomic Energy Commission, will report at Republic on July 1. Since 1952 Dr. Petersen has devoted his time to a study of the use of atomic energy for peaceful purposes with special attention to the construction of reactors, the atomic power plant. He will study and develop the use of nuclear materials in the operation of steel plants and in the production of steel on a broad base.

Arthur W. Johnson, former assistant chief engineer of Arms Franklin Corp., has joined the engineering staff of the E. W. Bliss Co., rolling mill division. Mr. Johnson

ARTHUR W. JOHNSON

participated in the development of the "Weld-A-Matic Splicer," recently acquired by Bliss. Previously Mr. Johnson was associated with the McKay Machine Co.

Fred C. Foy, vice president and general manager of the tar products division of Koppers Co., Inc. since November, 1950, has been elected a member of the board of directors. Mr. Foy came to Koppers in 1948 as vice president and manager of its central staff sales department. In this capacity, he directed the development of sales policies and the coordination of the sales efforts in its six operating divisions. On November 2, 1950, he became vice president and general manager of the tar products division.

Thomas H. Brumagin was elected to the board of directors of the Ajax Flexible Coupling Co. Inc. Mr. Brumagin is chief engineer and has been associated with Ajax since 1946.

H. G. Bauer was appointed vice president and general sales manager of De Laval Steam Turbine Co. In his new duties, Mr. Bauer will assume supervision of all company sales activities. **W. A. Neumann** has resigned as vice president in charge of sales to assume new duties as executive vice president and treasurer of the De Laval Separator Co.

Joseph G. Keller has been named district industrial engineer of Republic Steel Corp., Youngstown Plant, succeeding **O. G. Robertson,** who has resigned. Mr.

JOSEPH G. KELLER

Keller is succeeded as assistant district industrial engineer by **John C. Talbott.** Mr. Keller joined Republic as a production clerk in 1937. He was named assistant district industrial engineer in 1948. Mr. Talbott joined Republic in 1937. In 1939 he became an industrial

JOHN C. TALBOTT

engineer in the Youngstown plant and in 1945 became industrial engineer for Republic's Dilworth Porter division in Pittsburgh. He returned to Youngstown in 1950.

J. A. (Drew) Farnsworth has been named contracting engineer for Heyl & Patterson, Inc. and **James P. Blair** has been named assistant chief engineer of the light equipment engineering division.

A. J. Tomasek was elected president of Walsh Refractories Corp. He was formerly executive vice president. **J. J. Duggan** was elected vice president and retains his former position as manager, glass refractory sales. **W. K. Schweickhardt** was promoted to vice

yours...
upon request

New 1954 Booklet on

Aire-Rectifier Exclusive Features

• This new booklet illustrates the many exclusive features that make the Lintern Aire-Rectifier the choice of practically every steel and industrial plant using air conditioning on crane cabs and pulpits — features which assure unequalled cooling and filtering of the air at the lowest possible cost — features which have proven their worth in hundreds of applications while keeping maintenance costs at a minimum.

With this new booklet and Bulletin AC-533 you can select the right model Aire-Rectifier for the particular temperature range of the crane in mind.

Accompanying the description is a chart of applications (type of crane operation) temperatures encountered, and model recommended for the particular conditions.

By selecting the air conditioner of the proper size for the job, substantial savings are possible as compared with buying a unit designed for high temperature ranges when one for lower temperatures would answer the purpose satisfactorily.

Ask for Bulletins AC-544 and AC-533—yours free upon request.

THE LINTERN CORPORATION

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ROUTE 20, EAST • PAINESVILLE, OHIO

president and continues as manager of refractory sales. **Paul L. Hershfield** remains chairman of the board of the corporation and chief executive officer.

Carroll Cone has been appointed chief engineer of the industrial divisions and **William H. Dailey** has

CARROLL CONE

been appointed chief engineer of the steel mill division of Surface Combustion Corp.

WILLIAM H. DAILEY

Harvey W. Ball has been appointed technical advisor to the president of Morgan Engineering Co. **Charles F. Simmers** was named assistant director of engineering of the company.

John W. Frazier has been named field manager of air filter sales by American Air Filter Co., Inc. He served as general sales manager of Trion, Inc. during the past seven years. With headquarters in Pittsburgh, he will work with the various district sales offices of the company over the nation.

Leonard R. Constantine has been appointed plant manager of the Catasauqua, Pa., plant of the Fuller Co.

Crawford B. Murton has joined the sales department of Vesuvius Crucible Co. He was formerly sales representative for Kaiser Aluminum & Chemical Sales, Inc., refractory division, and has had open hearth

What's this?

. . . a hydraulic pump unit. But there's more to it than meets the eye.

The PRESSURE it develops is infinitely ADJUSTABLE, yet NO RELIEF VALVE is used, and thus no power is wasted.

If desired, the VOLUME of oil delivered can also be infinitely ADJUSTED . . . or reversed . . . WITHOUT using a FLOW CONTROL VALVE.

NO OIL COOLER is normally required, even though this unit can run CONTINUOUSLY at 3000 p.s.i.

All the types of CONTROLS for this pump are out where they can be seen . . . not hidden inside. They are SIMPLE both in basic design and operation.

And the variety of controls . . . well, why not write for the details as applicable to your particular requirements!

Quality EQUIPMENT for *Quality* PERFORMANCE

BENJAMIN LASSMAN & SON Route 8, GLENSHAW, PA.

operating and metallurgical experience at Inland and Wisconsin Steel Works.

W. W. Frymoyer has been elected a vice president of the Foxboro Co. Joining the firm in 1926, Mr. Frymoyer served as director of research and in 1939, was appointed general superintendent. Since 1951 he

W. W. FRYMOYER

has been factory manager and will continue in this capacity, supervising all instrument manufacturing activities of the company. He was formerly connected with the National Bureau of Standards, Washington, D. C.

Hermann A. Bottenhorn has been elected vice president in charge of the rolling mill division of Hydropress, Inc.

HERMANN A. BOTTENHORN

James M. Mead has been elected a vice president and director of Joseph T. Ryerson & Son, Inc. He succeeds **Ainslie Y. Sawyer,** who is retiring. Also elected to the Ryerson board is **Russell L. Peters,** financial vice president of Inland Steel Co., succeeding **Everett D. Graff,** retired, who was president of the Ryerson company from 1937 to 1951. Mr. Mead, who has spent his entire business life with Ryerson, joined the company at its New York plant in 1919. He became a general sales representative in New York and northern New Jersey, and in 1938 was appointed assistant manager of the Ryerson plant in Philadelphia. Three years later he was named manager at Philadelphia where he served for five years before returning to New York to take over the managership of this plant. In 1952, Mr. Mead was promoted to assistant vice president with headquarters at the Ryerson Chicago plant. In his new executive capacity he is in charge of procurement for the company's nation wide group of 16 steel service plants.

Hugo Lorant, vice president and member of the board of Hydropress, Inc., has been elected senior vice

HUGO LORANT

president. **Paul Mayer** became assistant vice president of the company.

R. A. (Buck) Hastings, formerly vice president of Continental Industrial Engineers, Inc., has joined Lindberg Engineering Co. Mr. Hastings will head the sales department of a new division of the company.

Alan D. Dauch has been appointed vice president of sales of Salem-Brosius, Inc., and of its recently acquired subsidiary, the George J. Hagan Co. In addition, Mr. Dauch will continue as vice president in charge of activities of the Hagan organization. **John W. Holzwarth** is the manager of sales of heavy heating furnaces for the steel and non-ferrous metals producing and fabricating industries and of all mechanical products. Mr. Holzwarth will have headquarters at the company's general offices in Salem, Ohio. **Charles H. Schwerin** was named manager of sales of rotary hearth furnaces and all heat treating furnace equipment.

Obituaries

Alfred W. Ward, chairman of the board of the Brooks Oil Co., died May 28. Mr. Ward had been associated with the company since 1919. He served as president from 1940 until 1949, and as chairman of the board since that time.

Charles R. Crane II, vice president and director of Crane Co., died May 8. He was 61 years of age. A grandson of the founder of Crane Co., Mr. Crane was associated with the company for 46 years. At the time of his death he had supervision over the executive policy of the company's subsidiary in England. He also handled special customer relations assignments.

2 more examples of THERMIT WELDING ECONOMIES

SOW BLOCK

Replacement of this damaged sow block for a 35,000-lb. forging hammer would have been costly and time consuming — Thermit repaired it quickly and economically.

48" MILL PINION

Weeks of costly idle time were saved by Thermit Welding the 28" neck instead of waiting for a replacement.

Thermit Welding is the answer to repair problems in many different plants—for a wide variety of equipment. Reasons:

- consistently sound welds
- minimum of technical skill required
- speedy repairs
- lower than replacement costs

INVESTIGATE THERMIT® WELDING

always ready to go to work

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THERMIT WELDING •
METALS & ALLOYS •
ARC WELDING—*Materials and Equipment* •
CHEMICALS & ANODES *for Electrotinning* •
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STABILIZERS *for Plastics* •
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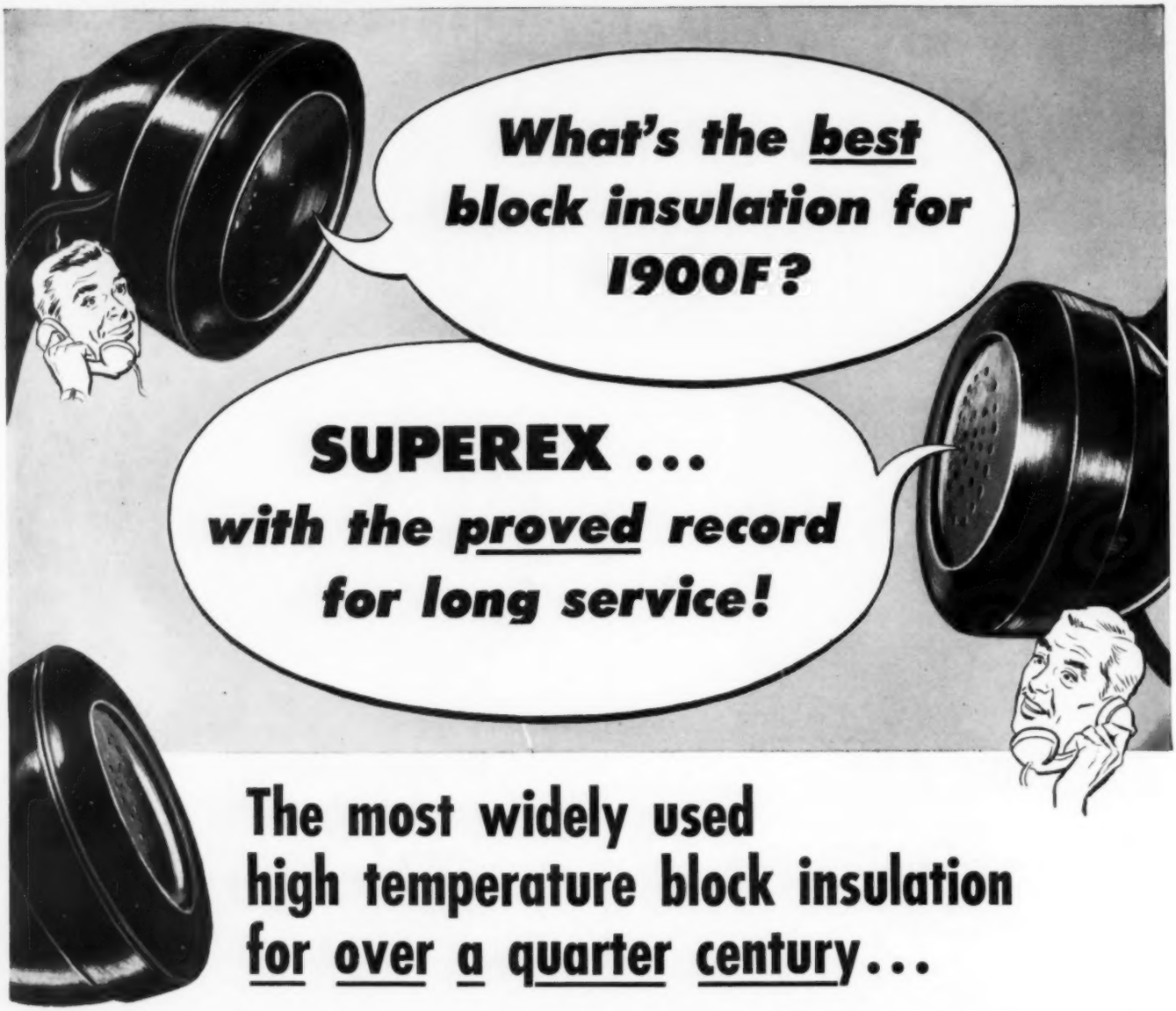


The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

These are the reasons why 90% of the nation's hot blast stoves are Superex insulated . . . and why the low cost open hearth steel producers use Superex in their regenerators.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, auxiliary power plant equipment, regenerators, kilns, roasters, high temperature mains, flues and stacks.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

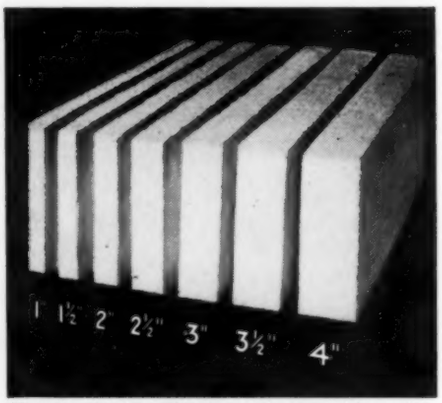
Light weight—Approximately 2 lb per sq ft per in thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex ⅛ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.



Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** *first in* **INSULATIONS**

Equipment News...

DRAFT INDUCER

▲ A new design of their furnace draft inducer, originally introduced in the 1920's, is announced by L. J. Wing Mfg. Co. Main features of the new design include interchangeable side panels, movable mounting feet, motor and fan assembly completely withdrawable, spring-mounted motor and v-belt drive to prevent mis-alignment, variable speed motor for precise draft control and pre-sealed bearings to eliminate periodic lubrication.

Interchangeable side panels, permit easy adaptation in the field to meet installation requirements for gas inlet and outlet openings. The four side panels surrounding the motor-fan unit may be unbolted and shifted as desired. A barometric damper may be used replacing one of the side panels.

As the entire unit is compact, it can be easily manipulated in the often limited space at the stack breeching—especially since only the casing need be handled. The motor-fan assembly may be inserted as a final step.

RUST INHIBITOR

▲ The Shell Oil Co. announces a new addition to its line of volatile corrosion inhibitors. Portions of this crystalline amine nitrite compound, VPI-250, volatilize very rapidly and will prevent rust almost immediately. At the same time, some of its constituents evaporate more slowly, for longer-lasting protection.

In addition to offering quicker yet longer rust prevention, the new material also flows more freely than any available heretofore. The compound, a white powder about as fine as talcum, will not clog a flocking gun, and can easily be applied with a squeeze bottle, a salt shaker, or any similar device. Where spraying or dusting is impractical, the powder may be dissolved in alcohol and applied in solution. Other methods of application are currently being tested.

The material does not have to be applied directly to the surface it is to protect. If a quantity of the powder is simply dropped into an enclosed space, its vapors will penetrate even into hard-to-reach areas and condense on all surfaces.

The minute crystalline film of VPI does not have to be removed from equipment before it is placed into operation, as would be the case with grease or petrolatum. Only small quantities of the material are required for complete protection in shipment or storage, or between successive processing steps. Small items, such as tools, can be removed from a VPI protected atmosphere, used, and then replaced without the need for any additional rust-preventive measures.

WELDING ELECTRODE

▲ A high speed welding electrode for horizontal and downhand welding, has been developed by Hobart Brothers Co. Best suited for faster welding on mild and medium carbon steel, this electrode is recommended for welding operations requiring AWS classes E6012 and E6020 electrodes such as machinery, low pressure storage tanks, and light structural work.

This contact type electrode has a high deposition rate with less physical effort in welding and less skill in operation required. It produces a high quality weld with a finely rippled bead approaching the appearance of a submerged arc weld. Spatter loss is exceptionally low and the slag is easily removed by a light tap.

TRAVELING BUCKET

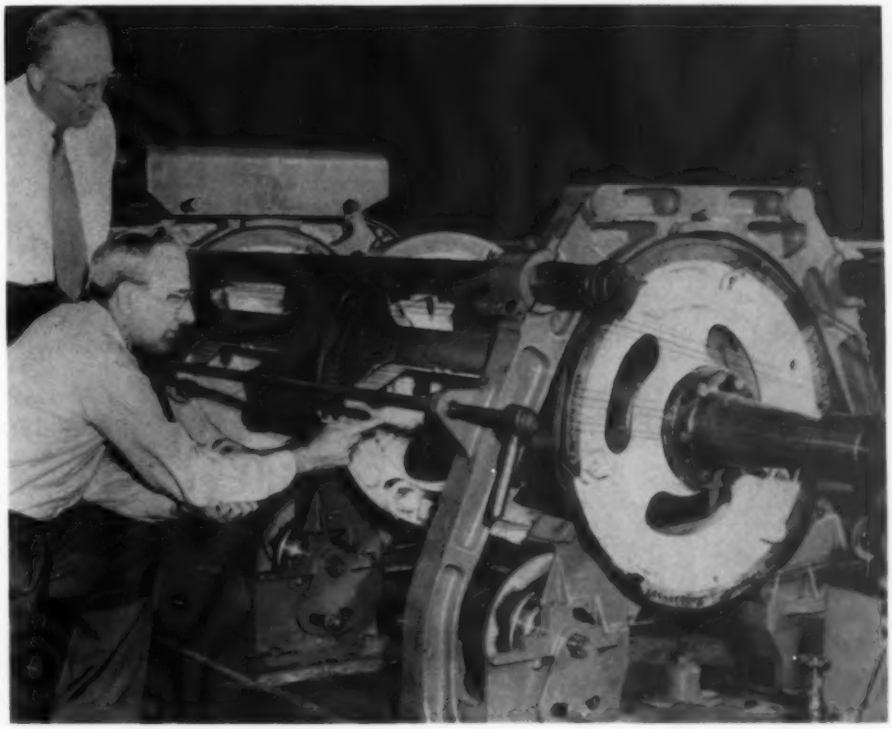
▲ A traveling bucket for handling dry granulated or lump materials and moist mixtures, including clay batch, has been developed by the Cleveland Crane & Engineering Co.

The unit is one of several engineered for the automatic dispatching of loads of damp clay batch from a mixer to two presses. The travel route includes a lift of 25 ft.

The bucket has a capacity of 22.5 cu ft and is rated at 2000 lb. It has a

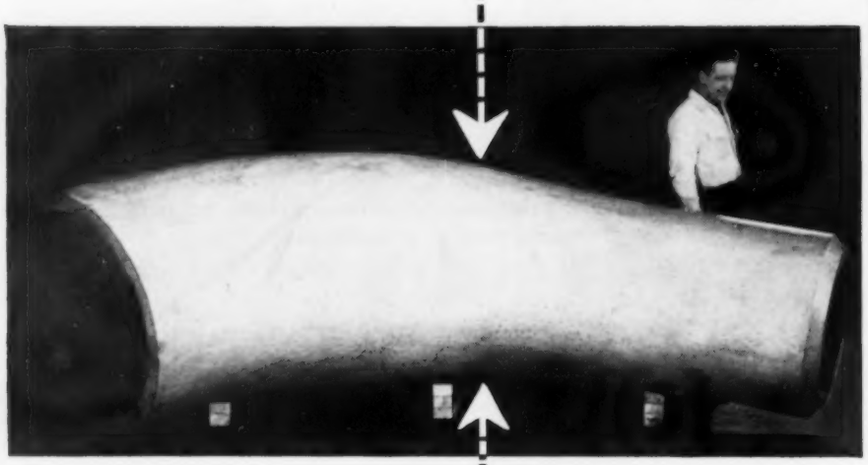
HIGH-SPEED WIRE STRANDER AT ROEBLING'S

Production of flexible wire rope for excavating shovels, cranes, and various types of hoists in the wire rope division of John A. Roebling's Sons Corp. will be accelerated with this new 175-ft high-speed wire strander. The new machine twists anywhere from 26 to 46 separate wires into strands for the fabrication of wire rope up to one and five-eighths in. in diameter. The rope made from these strands can lift loads up to 25 tons.



DURALOY

This Casting



Set a Record!

Casting weight
21,000 pounds

Shipping weight
14,000 pounds

Alloying Elements
38% Ni., 18% Cr., 2% Mo.

It's the weight rather than the Ni-Cr content that's the record.

We've cast many a piece with such a high Ni-Cr combination. But this represents the largest casting we have ever made. And it took careful scheduling of our entire battery of electric furnaces, with a double melt from two smaller furnaces.

Next followed a thorough X-ray for hidden flaws with our 400,000 volt unit. Then rough-finishing to specifications.

The significant fact is that this casting, the first of this size we have ever produced and destined for a most important high priority processing job, passed inspection with flying colors. *There was no reject here.* It is indicative of the skill of our metallurgists and foundrymen in turning out high alloy castings.

If you are looking for this kind of service, make Duraloy your casting source.

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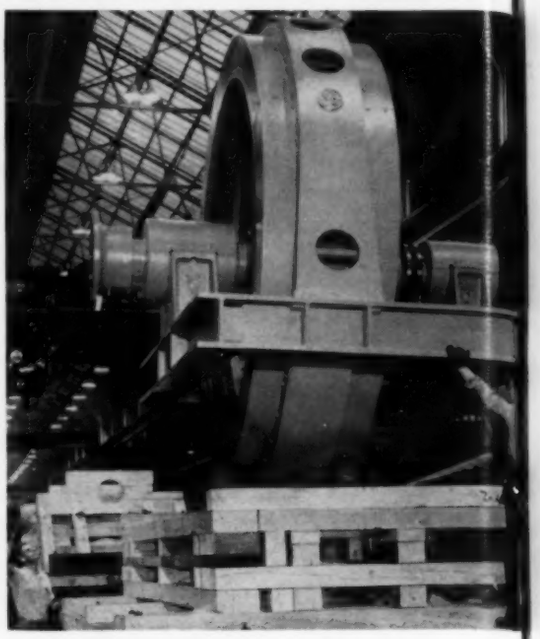
METAL GOODS CORP. Dallas • Denver • Houston • Kansas City • New Orleans • St. Louis • Tulsa

BALL-MILL MOTOR



The last of six high-torque, 1500-hp, 150-rpm synchronous ball-mill motors is loaded on a flat car at General Electric Co., Schenectady, N. Y., for shipment to the White Pine Copper Co., Mich. The motors will drive ball mills, each 12 ft long, 13 ft in diameter, and weighing about 300 tons, to turn these mammoth grinders the inherent high torque characteristics normal for ball-mill drives had to be incorporated into the motors. The mills are expected to grind 10,500 tons of low-grade (chalcocite) copper ore daily to bolster the nation's annual production of this key material by 75 million lb.

split-hinged gate that is operated by a motor which is protected by a box enclosure. The unusually wide opening of the gate facilitates discharge of slow moving, tacky materials.

WORM GEAR JACK

▲ Lifting overhead crane trucks for servicing — is being made easier by a heat-resistant worm gear jack with a sealed-in, grease-packed housing.

The worm gear jack is designed so that it can be installed as a permanent part of the crane after only a few slight modifications to the crane's structural sections. Permanent installation of the jack eliminates reliance on cumbersome, handpowered jacks.

When installed, the 25-ton capacity worm gear jack can be used to lift cranes for such repair jobs as replacing bearings, bushings and wheels and general lubrication. Built by Duff-Norton Manufacturing Co. —

LUBRICATING OIL
IS THE LIFE BLOOD OF YOUR MILL

...and DE LAVAL KNOWS HOW TO KEEP IT FLOWING AT TOP EFFICIENCY

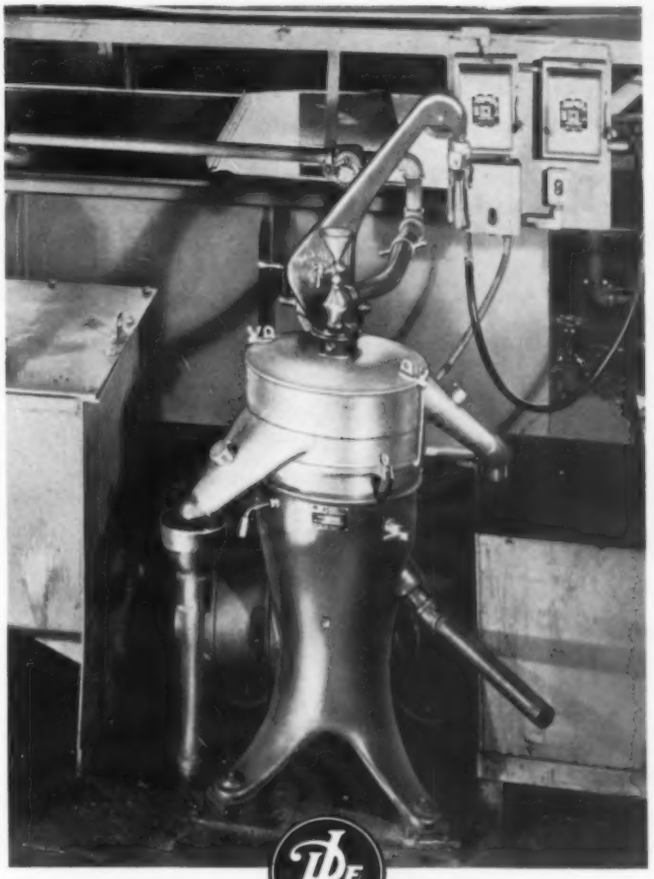
De Laval's ability to design custom-built mill lubrication systems is based on some thirty years experience.

As a consequence, De Laval knows exactly how the two prime essentials – adequate lubrication at every friction point and trouble-free operation – are best provided.

De Laval design incorporates correct metering, streamline flow, effective temperature control – and, where required, the finest oil purifying devices ... De Laval Oil Purifiers.

But, and equally important, when De Laval designs a system, the *details* are as well looked after as the principal elements. Piping is right, valves are right, tanks are right.

If you are planning a new mill or revamping an old one ... let De Laval take full responsibility for its lubrication. The size of the plant does not matter. De Laval designs complete systems for large mills – and provides self-contained De Laval Uni-Lube layouts for smaller ones.



THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York ● 427 Randolph St., Chicago 6
DE LAVAL PACIFIC CO., 61 Beale St., San Francisco 5

DE LAVAL

ENGINEERED MILL LUBRICATION SYSTEMS

the worm gear jack is ratchet operated.

Because the housing is packed in grease and sealed, heat and dirt won't affect the operation of the jack.

The jack, has a three and three eighth in. diameter lifting screw. The length of the screw varies according to the lift necessary to raise the truck off the track.

RECTIFIER BRAKE

▲ A new development that now makes it possible for a-c operated hoists and smaller capacity cranes to have more rugged and lasting dc brakes is announced by Harnischfeger Corp. Designated the "RCD" Brake, it marks the first time that dc rectifier brakes have been available for ac-operated equipment of this kind and capacity. This new brake with its sturdy selenium rectifier which has no moving parts eliminates the drawbacks of ac solenoids, most troublesome of which has been the erratic operation caused by loose laminations.

This new heavy-duty type rectifier brake provides direct action with very short stroke. With low voltage (24 volts) operating coils having fewer turns, inductance is less and action is quicker. Both setting and releasing of the brake are extremely fast, providing exceptional control in all hoisting and lowering operations. There is only one adjustment required, and up to three times longer lining wear is achieved.

The coil of the brake is sealed in pot with insulating type compound. The magnet pot and leads are stationary; there is no destruction of wires during brake operation. The entire assembly is of all-welded construction for maximum strength and durability.

BONDED BRAKE SHOE

▲ All gas-powered industrial trucks manufactured by Clark Equipment Co. are now equipped with bonded rather than riveted brake shoe and lining assemblies.

The process of cementing the brake lining on the brake shoe creates a more secure assembly and increases the life of the brake lining approximately forty per cent, it is claimed. The elimination of brake lining rivets adds substantially to the braking effectiveness. The new assembly is fully interchangeable with current production models.

Book Reviews . . .

▲ **"Temperature Measurement in Engineering,"** by H. Dean Baker, E. A. Ryder and N. H. Baker, published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 179 pp., 6 x 9 in., $3.75. It is the first of two volumes which will discuss temperature accurately in terms of engineering measurement. Presented here are facts needed to design, construct and operate an effective temperature measurement installation. The majority of situations encountered deal with thermocouple technique. Book includes full listing of various types of temperature-measuring instruments.

▲ **"The Sulphur Data Book,"** by the Technical Staff of the Freeport Sul-

FOR LONG-RANGE ECONOMY...
SPECIFY...
PYLE-NATIONAL
ENCLOSED FLOODLIGHTS
WEATHER-TIGHT . . . DIRT-TIGHT

For permanent, outdoor lighting installations, Pyle-National floodlights are the most economical in the long run.

Rugged, corrosion-proof materials and tight gasket sealing against dirt and moisture keep maintenance and replacement costs exceptionally low. Pyle-National floodlights will retain their original high efficiency output indefinitely. Many installations are still in excellent operating condition after 25 years of service!

Write for catalog 2100, which gives a complete description of our extensive line of heavy duty floodlights. Sizes: 10"-12"-14"-16"-20"-23". Sold nationally through electrical distributors.

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phur Co. has been published by McGraw-Hill Book Co., 330 West 42nd Street, New York 36, N. Y., 6 x 9 in., 142 pp, price $5. This is an indispensable reference book for use by engineers, chemists and students associated with sulphur. It brings together a wealth of important data on nature of sulphur, physical and chemical properties of sulphur, reaction thermodynamics, solubility of sulphur in various substances and methods of sulphur analysis. The book also includes conversion tables.

▲ **"Nuclear Physics,"** by W. Heisenberg, published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 5 x 7½ in., 225 pp., $4.75, presents a short and interesting history of the views about atoms in antiquity and the development of atomic theory until the close of the nineteenth century. The main subject of the book includes radioactivity, the binding energy of nuclei, nuclear structure, artificially induced nuclear transmutations and with the methods of observation and of producing nuclear transmutations. The book does not bring the subject up to date but is a provisional introduction to the subject.

▲ **"History of the Theories of Aether and Electricity,"** by Sir Edmund Whittaker, was published in 1954 by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 6 x 9½ in., 319 pp, price $8.75. The purpose of this volume is to describe the revolution in physics which took place in the first quarter of the twentieth century and which included the discoveries of special relativity, the older quantum theory, general relativity, matrix and wave mechanics.

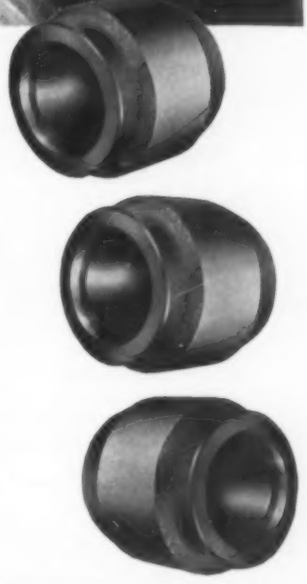
▲ **"The Heating Ventilating Air Conditioning Guide"** (1954 edition) has just been published by the American Society of Heating and Ventilating Engineers. Among the special features is a new chapter of Residential Summer Air Conditioning, new data on methods of obtaining local relief in hot humid environments, new information on recent developments in air and gas cleaning, new tables on steam requirements of process equipment, and more detailed data on characteristics of pipe and tube.

Recent research conducted by the Society, or sponsored at leading universities, has influenced changes, revisions and additions to a large proportion of the chapters. The large 24 x 32 in. ASHVE Psychrometric Chart, printed in two colors, is included. The guide is 6 x 9 in. in size, bound in blue cloth cover, stamped in gold, and is similar in appearance to previous editions. The price of single copies of this edition is $10.

▲ **"The Composition and Assaying of Minerals,"** by John Stewart-Remington and Dr. Wilfrid Francis was recently published by The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 5½ x 8½-in., 128 pp, price $5.50. Book discusses primarily the chemical composition of minerals with the object of providing a guide for their qualitative and quantitative examination.

USE THE ENGINEERING MART

MEEHANITE® ROLLER TWIST GUIDES
Cast by Rosedale Provide
1. LONGER SERVICE LIFE
2. LOWER INITIAL AND MAINTENANCE COSTS
3. REDUCED DOWN TIME



TYPICAL of the Meehanite castings made by Rosedale Foundry and Machine Company to solve "tough" problems for the steel industry are the roller guides shown in operation above.

On billet and bar these rollers have set tonnage records ranging from 60 to 70,000 tons per pair. Their initial cost is a fraction of the materials which they have replaced. Maintenance costs and down time are at a minimum since these tonnages are being obtained without re-grinding or re-surfacing.

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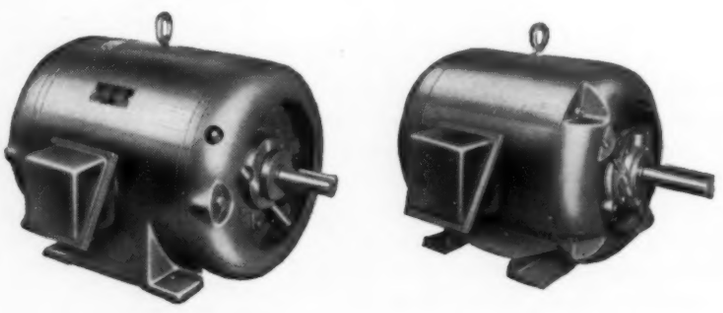

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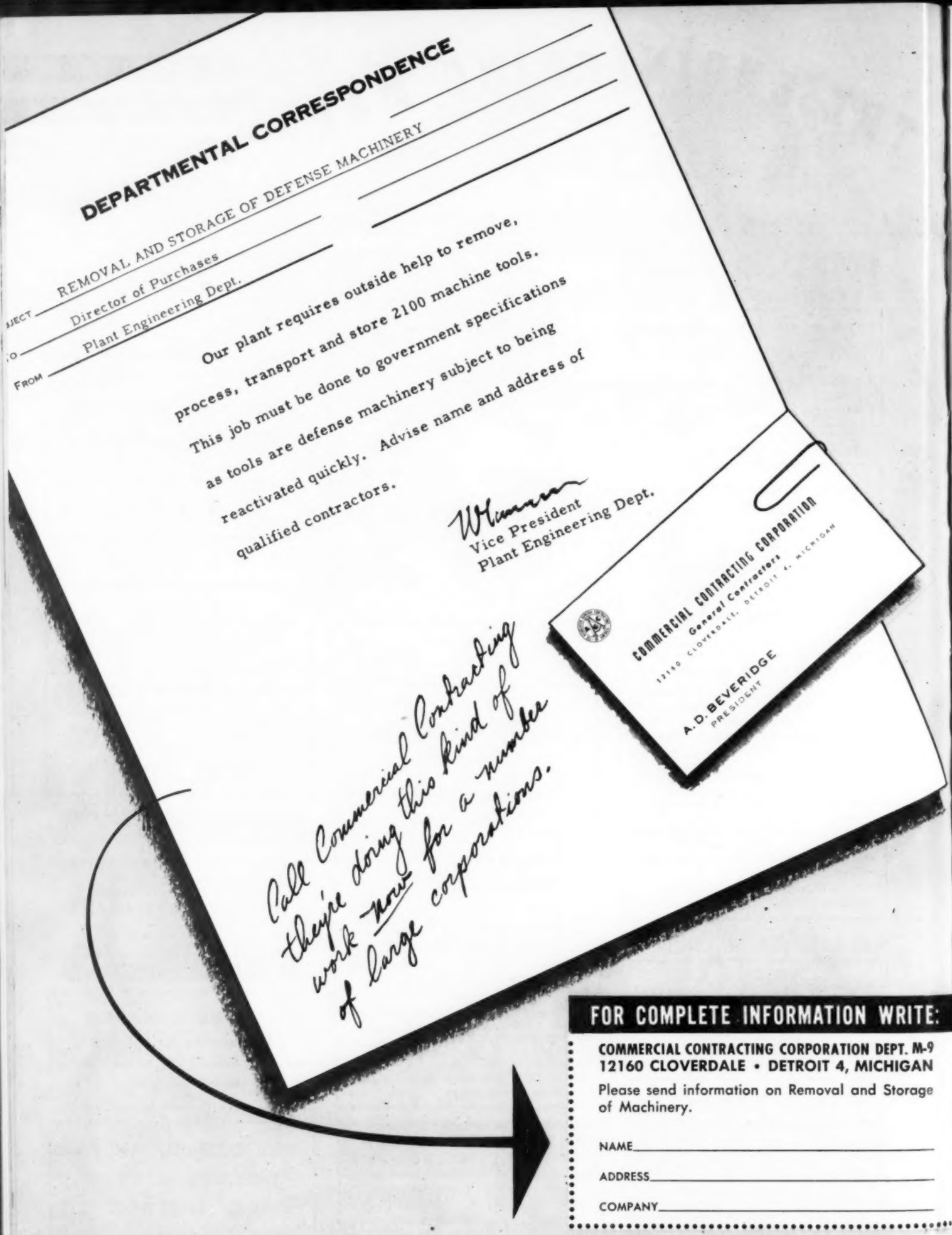
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INDEX TO ADVERTISERS

JUNE, 1954

A — Aetna-Standard Engineering Co. F-102, F-103
Air Products, Inc. 164
Ajax Flexible Coupling Co. 29
Aldrich Pump Co., The 144
Alliance Machine Co. F-36, F-37
Allied Chemical & Dye Corp., Wilputte Coke Oven Division F-136, F-137
Allis-Chalmers Manufacturing Co. 42, F-19, F-20, F-21, F-22
American Air Filter Co. 124
American Brake Shoe Co., American Brakeblok Division 153
American Brake Shoe Co., Electro-Alloys Division 37
American Brake Shoe Co., National Bearings Division 33
American Bridge Division, U. S. Steel Corp. 123
American Chemical Paint Co. 154
American Wheelabrator and Equipment Corp. 121
Ampco Metal, Inc. 138
Askania Regulator Co. F-135
Atlas Car and Manufacturing Co. F-118

B — Bailey Co., William M. F-119
Bailey Meter Co. F-106, F-107
Bedford Foundry and Machine Co. F-152
Birdsboro Steel Foundry and Machine Co. 117
Blaw-Knox Co. F-148, F-149
Blaw-Knox Co., Machinery Division 172
Blaw-Knox Co., Power Piping and Sprinkler Division F-31
Bliss Co., E. W. F-34, F-35
Bristol Co., The 188
Brooks Oil Co. 3
Browning and Co., Inc., Victor R. 134

C — Chemsteel Construction Co. F-134
Cities Service Oil Co. 139
Clark Controller Co. F-17
Clark Equipment Co., Ross Carrier Line, Industrial Truck Division 34
Cleveland Crane and Engineering Co. 38
Cleveland Worm and Gear Co. F-155, Cover 3
Columbia Electric Manufacturing Co. 167
Commercial Contracting Corp. 186
Continental Foundry and Machine Co. F-44, F-45
Crane Co. F-43
Crouse-Hinds Co. 14
Cunningham Co., M. E. 167
Cutler-Hammer, Inc. Cover 2

D — De Laval Separator Co. 181
De Laval Steam Turbine Co. 4
Diamond Power Specialty Corp. 166
Documentation and Licenses, Paris, France 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Dowell, Inc. F-16
Dravo Corp. F-27, F-61
Drever Co. 130
Duraloy Co., The 180

E — Eichleay Corp. F-31, F-32
Electric Controller and Manufacturing Co. 13, F-150, F-151
Electric Furnace Co., The 155
Electric Machinery Manufacturing Co. F-98
Electric Products Co., The F-144, F-145
Electric Service Manufacturing Co. F-58, F-59
Electro Chemical Engineering & Manufacturing Co. F-12
Elliott Co. F-132, F-133
Enterprise Co., The F-5

F — Factory Stores F-49
Farrel-Birmingham Co., Inc. 146
Farrell-Cheek Steel Co. 127
Farval Corp. F-156
Fischbach & Moore, Inc. F-122
Flinn & Dreffein Engineering Co. 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Foster Co., Inc., J. M. F-47
Foxboro Co., The 137
Frazier-Simplex, Inc., Interlocking Arch Dept. F-57

G — Garlock Packing Co. F-54
General Electric Co. F-39, F-40, F-41, F-42
General Motors Corp., Hyatt Bearings Division F-9
Gibbs and Hill, Inc. F-128
Gulf Oil Corp. 132, 133
Guyan Machinery Co. 165

H — Hagan Corp. F-130, F-131
Hallden Machine Co., The 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Harnischfeger Corp. F-111
Hazen Engineering Co. F-140, F-141
Heppenstall Co. 128
Heyl and Patterson, Inc. 16
Hunt and Son, Inc., C. B. F-124
Hyde Park Foundry and Machine Co. 165
Hydropress, Inc. 6

I — Ingersoll-Rand Co. F-143
Iron and Steel Exposition F-153
I-T-E Circuit Breaker Co. F-10, F-11

J — Johns-Manville Corp. 32, 178

K — Kaiser Aluminum and Chemical Corp. 148
Kennametal, Inc. 161
Koppers Co., Inc. F-38, F-116, F-117, F-129, 157

L — Lassman and Son, Benjamin 175
Leeds and Northrup Co. 10
Linde Air Products Co., Division of Union Carbide and Carbon Corp. 168
Link-Belt Co. 7, F-14, F-15
Lintern Corp., The 174
Loftus Engineering Corp. F-6, F-7

M — Mackintosh-Hemphill Co. F-55
Mannesmann-Meer Engineering and Construction Co. F-18
Manning, Maxwell and Moore, Inc. (Shaw Box Division) 149
McDanel Refractory Porcelain Co. 167
McKee and Co., Arthur G. F-126, F-127
Medart Co., The 152
Mesta Machine Co. Cover 1, F-93, F-94, F-95
Metal and Thermit Corp. 177
Miles and Partner, John, London, Ltd. 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Minneapolis-Honeywell Regulator Co. 40, 41
Morgan Construction Co. F-48, F-123

N — Nagle Pumps, Inc. 166
National Carbon Co., Division of Union Carbide and Carbon Corp. 1, F-60
National Roll and Foundry Co., The 2

O — Ohio Steel Foundry 150
Okonite Co., The 36

P — Pangborne and Co., Inc., W. V. F-120
Patterson-Emerson-Comstock, Inc. F-29, F-30
Pennsylvania Transformer Co. 143
Pittsburgh Lectromelt Furnace Corp. 44
Plasteel Products Corp. 136
Pollock Co., William B. F-13
Poole Foundry and Machine Co. F-138
Post-Glover Electric Co. F-46
Pyle-National Co., The 182

R — Ramtite Co., The F-125
Reliance Electric and Engineering Co. F-52, F-53
Riggs Distler and Co., Inc. F-100, F-101
Riley Stoker Corp. F-50, F-51
Ritter Engineering Co. F-147
Roberts and Schaefer Co. 160
Rockbestos Products Corp. 118
Rollway Bearing Co. 135
Rosedale Foundry and Machine Co. 183
Rowan Controller Co. F-97
Rust Furnace Co. F-2
Rust-Oleum Corp. 31

S — Sargent Electric Co. F-104
Simmons Machine Tool Corp. 145
Simonds Abrasive Co. 35
SKF Industries, Inc. F-28
Smith and Son, Inc., Charles F. F-142
Spraying Systems Co. F-115
Stamco, Inc. F-110
Stearns Magnetic, Inc. 159
Sun Oil Co. 147
Sutton Engineering Co. F-33
Swindell-Dressler Corp. F-8

T — Taylor Sons Co., The Charles 171
Taylor-Wilson Manufacturing Co. F-105
Texas Co., The Cover 4
Timken Roller Bearing Co., The F-139
Titzel Engineering, Inc. F-154
Tool Steel Gear and Pinion Co. F-112, F-113
Torrington Co., The Bantam Bearings Division F-108, F-109
Trabon Engineering Corp. F-146
Treadwell Co., Inc., M. H. F-121
Treadwell Construction Co. F-4
Trufio Fan Co. 158

U — Union Carbide and Carbon Corp., Linde Air Products Co. 168
Union Carbide and Carbon Corp., National Carbon Co. 1, F-60
United Engineering and Foundry Co. F-3
United States Graphite Co. 140
Universal Concrete Pipe Co. F-114

W — Wagner Electric Corp. 184
Walsh Construction Co. F-99
Waterbury Farrel Foundry and Machine Co. 162
Wean Engineering Co. 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Wean Engineering Co. of Canada, Ltd., The 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Wean Equipment Corp. 17, 18, 19, 20, 21, 22, 23, 24, F-23, F-24, F-25, F-26
Wellman Engineering Co. F-96
Westinghouse Electric Corp. 25, 26, 27, 28
Wilson Engineering Co., Inc., Lee 5
Wing Manufacturing Co., L. J. 163

Y — Yoder Co. 166
Youngstown Alloy Casting Corp. 8, 9
Youngstown Foundry and Machine Co., The 30
Youngstown Welding and Engineering Co. F-56

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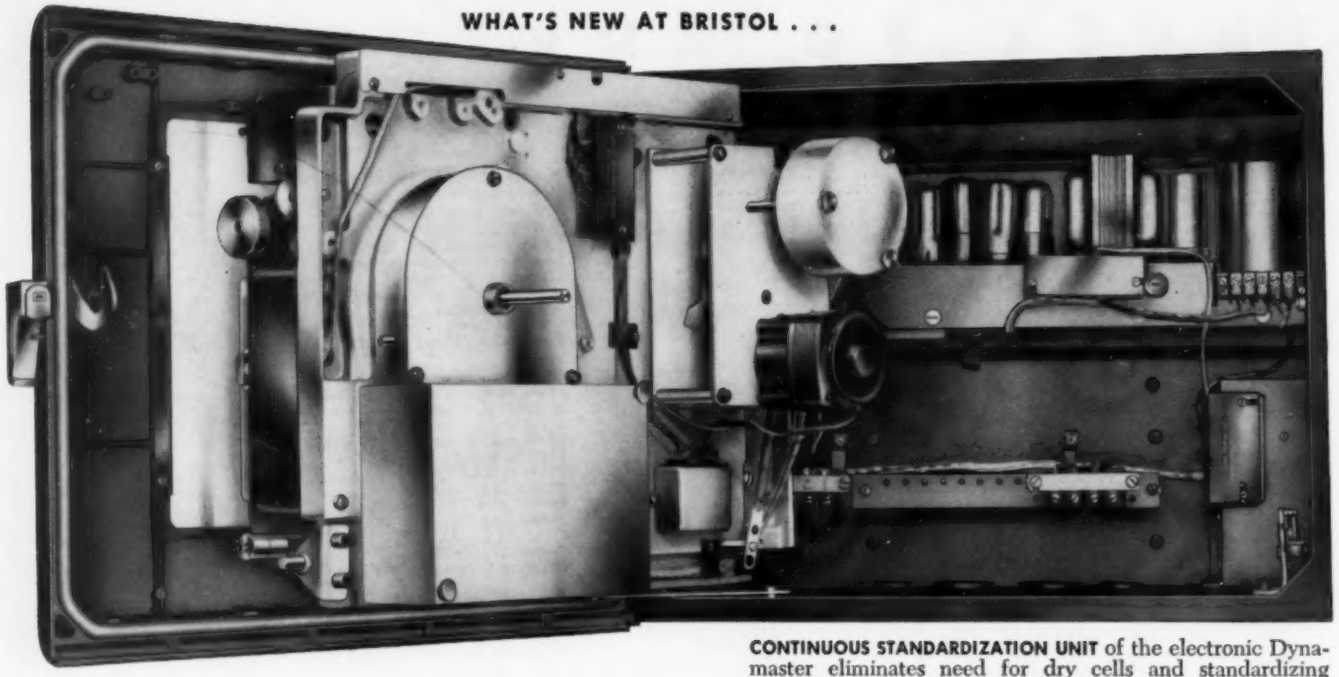

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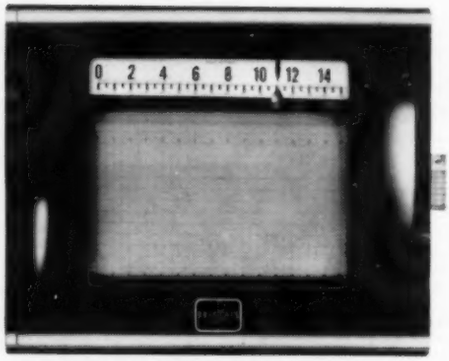

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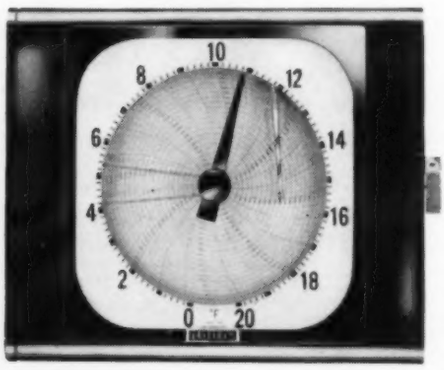

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